

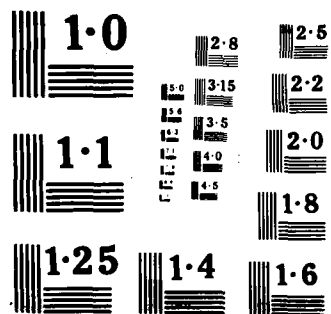
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THE CAUSES AND COSTS OF MODIFICATIONS TO
MILITARY CONSTRUCTION CONTRACTS

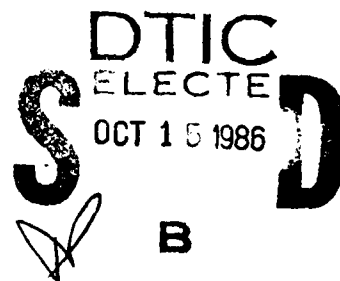
A thesis presented to the Faculty of the U.S. Army
Command and General Staff College in partial
fulfillment of the requirement for the
degree

MASTER OF MILITARY ART AND SCIENCE

by

ERIC T. MOGREN, MAJ, USA
B.S., State University of New York College of
Environmental Science and Forestry, 1974
M.S.E., University of Texas at Austin, 1984

Fort Leavenworth, Kansas
1986



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<p>This study identifies the causes and costs of changes to military construction contracts and discusses how excessive project cost growth can be reduced by thorough using service, constructibility, and technical design reviews.</p> <p>25 military construction projects, administered by the Corps of Engineers, were identified for study. Project files were reviewed to determine the reasons for and costs of 778 items of change contained in 268 modifications. Project cost growth was correlated by reviews conducted, project size, project type, and design agency. The study found the major causes of mods to be design deficiencies, user requested changes, and unknown site conditions. Most design deficiencies were found to occur in architectural aspects of design, followed by the mechanical, then electrical design disciplines. (Continued on back)</p>			
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The study further found that projects receiving technical, constructibility, and using service reviews had significantly lower overall cost growth than projects not receiving all three reviews. However, the lack of any one review could lead to cost growth increases regardless of the detail in which the remaining reviews were conducted. Less expensive O&I and AFH projects tended to have higher cost growth rates than more costly M&A projects, apparently due to the higher priority given to design and review of large projects. In-house designs were found to have lower cost growth than designs by contracted private A/E firms largely due to greater problems with unknown site conditions experienced by A/E designed projects.

The study also examined the design review system. Information on reviewer training and experience, time available, and review procedures was collected by question aire. It was found that the primary reason for poor quality reviews was lack of time brought about by competing work requirements.

The findings of this study were compared with the findings of 16 related works in order to evaluate the external validity of the results. A strong correlation between most of the findings was found to exist, particularly in the areas of modification causes and the effect of good reviews on cost growth reduction.

The study concludes that the major causes of modifications to military construction contracts are design deficiencies, user requested changes, and unknown site conditions. Thorough design reviews can decrease the rate and cost of modifications in these areas. Reviews must be properly managed, however, to insure they receive the priority needed to be effective.

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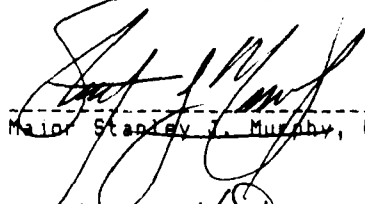
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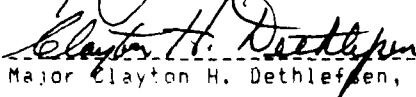
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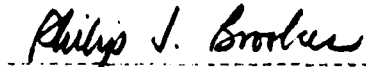
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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General College or any other governmental agency. (References to this study should include the following statement).

ABSTRACT

THE CAUSES AND COSTS OF MODIFICATIONS TO MILITARY CONSTRUCTION
CONTRACTS, by Major Eric T. Mogren, USA, 199 pages.

This ^{study} study identifies the causes and costs of changes to military construction contracts and discusses how excessive project cost growth can be reduced by thorough constructibility, using service and technical design reviews.

25 military construction projects, administered by the Corps of Engineers, were identified for study. Project files were reviewed to determine the reasons for and costs of 778 items of change contained in 268 modifications. Project cost growth was correlated by reviews conducted, project size, project type, and design agency. The study found the major causes of mods to be design deficiencies, user requested changes, and unknown site conditions. Most design deficiencies were found to occur in architectural aspects of design, followed by the mechanical, then electrical design disciplines.

The study further found that projects receiving technical, constructibility, and using service reviews had significantly lower overall cost growth than projects not receiving all three reviews. However, the lack of any one review could lead to cost growth increases regardless of the detail in which the remaining reviews were conducted. Less expensive OMA and AFH projects tended to have higher cost growth rates than more costly MCA projects, apparently due to the higher priority given to design and review of large projects. In-house designs were found to have lower cost growth than designs by contracted private A/E firms largely due to greater problems with unknown site conditions experienced by A/E designed projects.

The study also examined the District's design review system. Information on reviewer training and experience, time available, and review procedures were collected by questionnaire. It was found that the primary reason for poor quality reviews was lack of time, brought about by competing work requirements.

The findings of this study were compared with the findings of 16 related works in order to evaluate the external validity of the results. A strong correlation between most of the findings was found to exist, particularly in the areas of modification causes and the effect of good reviews on cost growth reduction.

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Eric T. Mogren
Major, Corps of Engineers

Fort Leavenworth, Kansas
9 May 1986

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CHAPTER 1

INTRODUCTION

Background:

The Department of Defense annually spends billions of dollars on military construction. Much of this is managed by the United States Army Corps of Engineers. The Government's trend over the last few years has been to increase the amount budgeted for construction, as shown in Table 1. This trend is likely to be reversed, however, because the spiraling federal deficit has resulted in increasing pressure to reduce overall defense spending. Consequently, it will become increasingly important to spend each defense dollar more efficiently. The Corps of Engineers can assist in this effort by reducing contract modifications and accompanying project cost increases.

TABLE 1
The Trend in DOD Military Construction Spending (1)

Fiscal Year (\$ Millions - FY 86 Dollars)						
<u>1976</u>	<u>1980</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>	<u>1986 (Projected)</u>
4,326	2,969	5,756	5,076	4,872	5,724	7,057

The potential for savings in construction contracting is substantial. Corps of Engineers contract audits are credited with saving \$20.1 million in FY 1984 as part of the Inspector General's efforts to curb waste, fraud, and abuse (2). There is much more, however, that can still be done. Table 2 summarizes findings from three previous studies on construction contract cost growth. All projects shown were federally funded, although not all of them were administered by the Corps of Engineers. Table 2 is simplistic; it does not take into account project size, project type, scope of work, period over which the data was collected, or other factors which may influence cost growth. When the percentages in Table 2 are applied to the budget amounts shown in Table 1, it is obvious that savings of millions of dollars are possible if cost growth is reduced by only a few percentage points per project.

TABLE 2
Cost Growth on Federally Funded Projects

Study	Number of Projects	Summed Original Cost of all Projects	Percentage Cost Growth		
			Minimum	Maximum	Average
Rosmond (3)	300	\$333,354,000	-	-	8.3%
Diekmann (4)	22	\$103,900,000	-4.5%	72.5%	4.8%
Rowland (5)	20	\$ 81,053,000	0.4%	24.0%	7.1%

NOTE: Numbers in parenthesis in column 1 are keyed to chapter endnotes. Note that Rosmond's study only reported average cost growth; the maximum and minimum figures were not given.

Military construction contracts are normally awarded by the Corps of Engineers on a lump sum, competitive bid basis. The purpose

of this system is to insure the government obtains a project built to the specifications and schedule desired at the lowest possible price. This system is also designed to protect the contractor by providing him all known project requirements prior to bid submission. Theoretically, at the time the contract is awarded, both parties know what the contract requires, when it is to be done, and what it will cost.

A contract modification is defined as "any written alteration in the specification, delivery point, rate of delivery, contract period, price, quantity, or other contract provisions of an existing contract, whether accomplished by unilateral action in accordance with a contract provision, or by mutual action of the parties to the contract." (6) The Corps of Engineers divides modifications (or "mods") into two categories. The first category is "change orders". Change orders are changes to the contract that fall within the contract's general scope of work, and are governed by the "changes" clause of the standard construction contract. (7) The second category of mod is "supplemental agreements". Supplemental agreements are changes that fall outside the original scope of the contract. A supplemental agreement "is therefore a new negotiated contract which must be founded upon offer, acceptance, and consideration." (8) The supplemental agreement is added as a supplement to the existing contract for administrative convenience.

Once a construction contract is awarded, any changes to that contract are processed as modifications. Any changes outside the original contract scope or beyond the contractor's control (such as excessive periods of bad weather) may entitle the contractor to

additional compensation, time, or both. Unlike the original contract, which was competitively bid, modifications are most often "sole source" procurement actions. The net result is that contract modifications place the government in a less than ideal bargaining position and usually involve an increase in construction cost. As Lloyd Finley stated in his study of constructibility reviews:

"Any such required adjustment (or change order) becomes, in effect, a separate, sole source agreement, lacking in the competitive atmosphere present during contract award and significantly impacting the ability of the government to assume the best (or lowest) cost for the work." (9)

The cost of modifications can be measured in ways other than just direct construction costs. Indirect costs are incurred for processing, negotiating, and coordinating contract changes. These actions also consume a great deal of time that could be better spent elsewhere. Often modifications result in time extensions that push back project completion dates. These delays, in turn, upset the customer's scheduled use of the facility. Finally, projects with high cost overruns and excessive delays negatively impact on the Corps professional reputation. Therefore, reducing the number of "mods" can save taxpayer dollars, allow the Corps greater productivity, and provide a more professional and timely product to the supported installation.

Data collection for this study was conducted between February 1985 and August 1986 from 25 military construction projects administered by the Corps on an Army installation. These included projects funded under the Military Construction, Army (MCA), Operations and Maintenance, Army (OMA), and Army Family Housing (AFH) programs.

The supporting District was located about 40 miles from the installation upon which construction took place.

The goal of this study was to determine the causes and costs of contract mods and to determine why design reviews were failing to identify problems prior to construction. An additional goal was to determine how applicable the findings from this relatively limited sample of projects were to military construction in general by comparison with findings from other studies. This thesis summarizes the methodology, data, and findings of that effort.

Research Objectives and Problem Statement:

The research objectives of this thesis were to:

1. identify the level of cost growth of sample MCA, OMA, and AFH construction projects.
2. identify the reasons for modifications to military construction contracts.
3. determine the administrative overhead costs of modification processing.
5. determine if the design review system used by the supporting District was adequately catching potential problems prior to construction, thereby precluding the need for all or most later modifications.
6. determine if the situation observed was unique to the installation under study or if it was consistent with situations described in other studies.

This study addressed those objectives by asking the following research questions:

1. Did project cost growth at the installation exceed acceptable levels?

2. How much did modification administration and overhead cost the District in terms of time, money, and productivity?
3. What were the causes of contract modifications?
4. Did the current design review system adequately identify and correct problems prior to contract award? If not, why?
5. Do the findings of this study track with findings of modification studies conducted elsewhere? Are the findings of this study applicable to Corps military construction in general?

The paper was organized to examine each question in the following sequence. Chapter 2 presents an overview of related studies and writings on the subject of construction contract modifications. Chapter 3 is a detailed description of the methodology used to collect data from the projects selected for study.

Chapter 4 presents data on modification costs and causes by addressing both direct and indirect costs. Data for this Chapter were collected from primary source contract documents. Mod cost and causes were examined by project type, project size, design agency, and by whether preconstruction reviews were conducted on project design prior to start of construction. The purpose of this cross-correlation was to determine the influence, if any, each of these categories has on contract mods.

Chapter 5 discusses the preconstruction review system and examines why reviews seemingly failed to identify potential problems prior to project start. Most of the data for Chapter 5 came from

questionnaires completed by District personnel involved with the review process.

Chapter 6 compares the findings and conclusions of this study with those findings and conclusions stated in the other papers discussed in Chapter 2.

Chapter 7 summarizes this study's findings and conclusions, and identifies areas requiring further study. Operational definitions, data tables, and a summary of questionnaire responses are included in appendices.

Assumptions:

The following five assumptions were made at the beginning of the study:

1. The impact of contract modifications can be quantified by:
 - a. Direct and indirect cost (dollars). Direct cost is the money paid to the contractor for labor and materials. Indirect cost is the cost for administrative overhead to the District.
 - b. Project cost growth (percentage).
 - c. Total number of mods per project.
 - d. Total number of changes per project. (Note that each modification may include more than one item of change.)
 - e. Time spent on mod negotiation, administration, and processing (manhours).
 - f. Impact cost. These are costs derived from the impact changes to the original design and schedule may have on elements not directly related to the modification. Impact cost, however, were not addressed in this study.

2. Most military construction projects will have some changes made during the course of construction. The Corps of Engineers does not formally define what these levels should be. Consequently, it is necessary to establish what an acceptable level of cost growth might be. Cost growth percentages were determined based on conversations with construction experienced personnel within the District and installation DEH. The percentages shown below represent a consensus of the opinions expressed during those interviews. These levels were determined to be:

- a. 3% for high cost, "from the ground up" new construction.
- b. 5% for new work in existing buildings and non-complex structural and/or architectural renovation work.
- c. 10% for renovation work involving complicated electrical or mechanical work, particularly where that work involves going inside the walls of older buildings.

These figures may fluctuate somewhat with the size of the project. For example, a low cost, complex renovation project may sustain a higher cost growth since the price of each change will consume a larger percentage of the original contract amount.

3. The quality of a preconstruction review is primarily dependent on three factors. Therefore, an evaluation of these factors provides an indicator of the quality of the reviews being performed. These factors are:

- a. The professional qualifications, education, training, and experience of the individual doing the review.
- b. The time available for the conduct of the review.

c. The organizational and procedural framework within which reviews are conducted. This includes the system by which review results are analyzed and appropriate action taken.

These review factors described above can be evaluated by the use of questionnaires filled out by those responsible for the conduct of reviews.

4. There are three types of preconstruction reviews that have a direct impact on modifications during construction. These are using service reviews, technical reviews, and constructibility reviews. The failure to thoroughly conduct any one of these may result in extensive cost growth regardless of the detail in which the other two are conducted.

5. Three of the 25 projects selected for study were not yet complete when final data were collected. These were projects #4 (96% complete), #19 (99% complete), and #22 (81% complete). It was assumed that these projects were substantially complete enough so that any additional mods incurred by them would not significantly alter the findings presented.

Constraints and Delimitations:

The following constraints and delimitations were identified during the course of the study:

1. Data were collected from Corps of Engineers, military construction projects only. No data was collected on civil works projects. Consequently, the findings and conclusions may not directly apply to civil works or work in the private sector.

2. The questionnaire used to evaluate the review system was distributed only to District employees involved with military construction.

3. In general, the search for previous studies and literature was limited to those completed since 1970. Older studies were used only if their methodology or findings had a direct and significant relationship to this study.

4. This study did not address the issue of contractors who deliberately submit low bids in the hope of increasing their profits by submitting requests for modifications or claims after construction begins.

5. This study did not address the issue of A/E liability for design deficiencies, errors, and omissions.

6. This study did not address biddability and operability reviews since internal District procedures usually resulted in these being done in conjunction with the technical and constructibility reviews. Furthermore, only District conducted reviews were examined. Reviews conducted by the installation Director of Engineering and Housing (DEH), Division Headquarters, or private Architectural/Engineering firms for the Corps were not addressed.

7. Data on indirect costs was limited due to District accounting procedures. The only indirect costs accounted for by individual project were engineering, design, and overhead. Costs associated with construction activities, such as bid negotiation and contract administration, were accounted for under an overall

construction account and not credited to individual projects. Hence, the data on indirect costs is not complete.

8. Initially, it was decided to not include disputed claims requiring litigation or arbitration. This turned out not to be a problem, however, since only one such claim was found in all 25 projects for a relatively small amount (\$100). With this one exception, all mods studied were agreed to by both parties and resolved by project completion.

Significance of Study:

16 studies, reports, journal articles, and other papers were identified which addressed the issues raised by the objectives of this study. No one of these, however, could be considered conclusive as each drew its conclusions from a necessarily limited data base. No study was found which attempted to analyze and correlate the findings of these diverse studies. Therefore, the value of this effort is twofold. First, it adds to the general modification knowledge base by adding to the pool of data previously collected. Second, it systematically compares the findings of the identified studies with the findings of this study to determine general trends appearing in military construction projects. Minor variations in these trends can be expected between individual locations. But in general they should provide the Corps as a whole with a general model of what causes modifications, how much they can be expected to cost, and what efforts should be made in the area of design review to preclude excessive cost

growth. By identifying the major causes of project cost growth, Districts should then be in a better position to more efficiently focus their review efforts to reduce overall construction costs.

Endnotes, Chapter 1

1. U.S. Department of Defense, Annual Report to the Congress: Report of the Secretary of Defense on the FY 1986 Budget, FY 1987 Authorization Request and FY 1986-90 Defense Programs, (Washington, D.C.: U.S. Government Printing Office, 4 February 1985), p. 293.
2. DOD, Annual Report to the Congress, p. 90.
3. James R. Rosmond, "Analysis of Low Bidding and Change Order Rates for Navy Facilities Construction Contracts", (Master's thesis, Naval Postgraduate School, Monterey, June 1984), p. 39 and p. 51.
4. James E. Diekmann and Mark C. Nelson, "Construction Claims: Frequency and Severity", Journal of Construction Engineering and Management, (Vol. 111, No. 1, March 1985), calculated from data on p. 76.
5. Henry J. Rowland, "The Causes and Effects of Change Orders on the Construction Process", (Master's thesis, Georgia Institute of Technology, School of Civil Engineering, November, 1981), figures calculated from data presented in Appendix B.
6. Construction Contract Negotiating Guide, (Office of the Chief of Engineers: Washington D.C., 1977), page 2-1.
7. Construction Contract Negotiating Guide, page 2-2.
8. Construction Contract Negotiating Guide, page 2-3.
9. Lloyd S. Finley, "Examination of the Constructability [sic] Review in Government Contracting", (Master's Thesis, Purdue University, School of Civil Engineering, 3 August 1984), page 4.

CHAPTER 2

SURVEY OF EXISTING PUBLICATIONS

General:

This chapter summarizes the findings of previous research projects and writings on construction contract modifications. This survey identifies 20 related studies, articles, and reports and provides a framework within which the relevance of the findings of this study can be evaluated. The ultimate objective is to determine if the findings of this study are consistent with the findings of these other works. A comparison between findings is made in Chapter 7.

In general, only publications or studies completed between 1970 and 1985 were reviewed. This 15 year period was arbitrarily selected in order to delimit the amount of material to be reviewed. Exceptions were made only if a particular work made a direct and significant contribution to the study of contract modifications. The publications reviewed are grouped under four categories:

1. Government publications. Includes regulations, pamphlets, and other documents establishing procedural guidance for military construction.
2. Official government studies. Includes studies carried out by government agencies or by civilian agencies under contract to the government.
3. Studies completed at academic institutions. Includes individual master's theses.
4. Articles from professional journals and magazines.

Publications were selected based on topic relevance and availability. Studies and theses were obtained through the Defense Technical Information Service (DTIC). Abstracts of professional magazines and journals, dating back to 1970, were reviewed for pertinent articles. Several reports and studies were obtained through the Corps' District administering the projects under study. Many of the papers surveyed did not directly deal with the topics covered in this study. In some cases, only a few pages (or at best a chapter) was dedicated to modifications. In other cases, the author collected the same types of data but used them to address different problems. This survey discusses only those items contained in existing works that relate to the two main issues of this paper: the sources and costs of modifications and the relationship of design reviews to modifications.

Government Publications:

The U.S. government publishes a number of documents regulating military construction. These begin with legislation enacted by the U.S. Congress, such as the Annual Military Construction Appropriation Act. Subsequent guidance is issued by the Department of Defense (DOD), Department of the Army (DA), the Corps of Engineers (COE), and Engineer Divisions and Districts responsible for project execution. The regulations written at each level are intended to establish the policies and procedures for implementation of guidance from higher authority.

Normally, guidance issued by the higher authorities tends to be more general in nature than that issued at the lower levels. Consequently, laws and regulations enacted at levels above the Chief of Engineers have little impact on day-to-day contract administration other than to provide a legal framework within which regulations issued at lower levels must comply. The regulations impacting most on military construction include ERs and District regulations listed in the bibliography. While they prescribe the procedures by which mods to military construction contracts are to be administered, they will not be discussed individually. Instead, the next few paragraphs center on three documents which summarize all these other regulations. These are Engineer Pamphlet (EP) 415-1-2 "Modifications and Claims Guide", the "Construction Contract Negotiation Guide", and a locally published "Resident Engineers Manual" used by the supporting District. These provide a good overview of how the procedure is to work.

EP 415-1-2, the "Modifications and Claims Guide", is issued as a guide only. It is not intended to supersede any regulation or contract requirement. The pamphlet is not directive in nature. Its purpose is to "provide a single source definition of the modifications and claims process which references all applicable regulations and relates their requirements in a coordinated manner." (1) It provides an excellent general reference document which clearly summarizes the essential requirements of applicable regulations. The pamphlet orients on those contract clauses dealing with mods and claims. It covers in detail initiation and processing procedures. The appendices include an

excellent glossary of terms, completed sample forms, and a regulation reference index. This pamphlet is an outstanding general reference on mod and claim procedures for construction contracts administered by the Corps of Engineers.

An excellent supplement to EP 415-1-2 is the "Construction Contract Negotiating Guide". (2) It is prepared by the Chief of Engineers' office as a training manual for personnel involved in contract and mod negotiations. As such, it also is not directive or regulatory in nature. There is some overlap between the material covered in these two documents. For example, both generically discuss the sources and types of modifications. The main difference is in orientation. Where EP 415-1-2 focussed on administrative procedures, the Negotiation Guide concentrates on topics related to negotiation of fixed-price contracts and mods. It includes discussion on pricing objectives, cost and profit analysis, negotiation procedures, and contract controversies. Like EP 415-1-2, this book is an outstanding reference for general background material.

The third government publication is District Regulation 415-2-1, the "Resident Engineers Manual". It provides an example of how higher level regulations are incorporated into operating instructions at the District level. Unlike the preceding two documents, this manual is directive in nature. Its purpose is

"to present and prescribe, in one publication, the basic duties, responsibilities, policies, procedures, and essential information for guiding Resident Engineers and their staffs in administering and inspecting construction contracts under their jurisdiction". (3)

The manual's applicability is limited to those projects under District

control. Researchers studying the issue of modifications within other Districts may want to determine if a similar local policy document exists. If so, it can be a valuable source of information on local procedures.

Government Studies:

Three general sources of government studies were found. The first was the U.S. Army's Construction Engineering Research Laboratory (CERL) which has published numerous papers related to contract modifications, two of which were used in this study. The second source was the Office of the Chief of Engineers, which initiated two panel studies to evaluate the areas of installation support and construction quality. Lastly, two studies were found which the Corps had contracted from the Texas A&M Research Foundation. These dealt with the application of operations research techniques to construction operations. Each study will be discussed, with the emphasis on those areas relating directly to the issues of this paper.

The findings of the most recent CERL study were released in USA-CERL Technical Report P-85/11, "Ways to Improve Construction Contract Modification Processing: USAFEA Korea Case Study". (4) This case study was completed by the U.S. Army Facilities Engineer Activity (USAFEA) in Korea and summarizes actions taken by that agency to improve mod processing within its area of responsibility. Broad application of the findings may be limited since many of the problems identified are unique to the Korean environment, such as high personnel turnover, regulations governing materials, the language barrier, and a

lack of computer automation. Furthermore, most of the projects in Korea consist of maintenance and repair work to five-year "temporary" facilities still in use after 25 years. But many of the recommendations can be applied in a general sense. These include the discussion on policies concerning user requested changes, destructive testing to verify site conditions, the need to perform oversight and follow-through on design review comments, the need for formal management controls on mod processing, the need for automated mod tracking systems, and the need for increased use of electronic communications.

Another CERL document was published in May 1985. This was the preliminary draft of the "Automated Review Management System (ARMS)".(5) This paper summarized the findings of a Corps wide survey conducted in 1983 and the results of numerous field visits, workshops, and interviews in 1984 concerning design reviews. The paper discusses the link between good reviews and reduced modifications. Those findings which pertain to this study include statements that 56% of modifications are due to design deficiencies, that too little time is being devoted to design reviews, and that current review procedures are not being centrally managed. ARMS was designed to provide a menu driven computerized management system to manage review suspenses, review comments, and develop a design review data base. It appears to be an excellent management tool with broad application.

The Chief of Engineers published the "Report of the Blue Ribbon Panel on Management of Construction Quality in the U.S. Army Corps of Engineers" in March, 1983. (6) The panel's mission was to find methods

to improve the quality of Corps construction, effectiveness of contractor quality control, and the level of Corps quality assurance administration. It did this by conducting workshops, interviews, questionnaires, site visits, and by reviewing previous studies, such as the Business Roundtable Reports. Modifications per se were not specifically addressed. Instead, the study focussed on general construction quality, and addressed issues such as review effectiveness, cross training between Design and Construction personnel, and the need to reduce the number of mods and change orders.

The "Report of the Green Ribbon Panel on U.S. Army Corps of Engineers Support to Army Installation Commanders" was prepared by the Chief of Engineers in March, 1985. (7) The purpose of the report was to recommend initiatives and improvements in Corps support to military installations. The report does not directly address modifications or their impact on installation support. Much of the report echoes the findings of the Blue Ribbon Panel completed two years earlier. The Green Ribbon Panel report emphasized the need for electronic automation to assist in installation support. It highlighted the need for rapid funding procedures to fix deficiencies. It cited the need for better review quality and the importance of review comment feedback. All of these issues were applicable to the situation observed during this study.

The Corps contracted for two studies from the Texas A&M Research Foundation in the late 1960's. "A Systems Approach to Design and Construction for the Corps of Engineers" was published in May 1968. (8) The purpose of the study was to determine the method of operation

the Corps uses to accomplish military construction and to structure this operation as a system. The study did an analysis of the military design and construction mission using systems engineering techniques. The study identified different sources of mods. Furthermore, it prescribed specific solutions to the problem of modification reduction. Among these solutions were more complete reviews, relief from statutory limitations on the amount of money set aside for reviews, and the delegation of greater authority to Resident Engineers. Though somewhat dated, this study provides excellent background material and recommendations that still apply.

The second study, a "Systems Analysis of Corps Design Engineering", was prepared in June 1969. (9) This study found eight problem areas in the Corps' design process, two of which relate to the subject of this paper. These are the areas of design data and design review, both of which will be discussed in subsequent chapters. The major strength of this study is its practical recommendations for solving the problems identified. Specific findings of interest here include the recommended use of checklists to assist in reviews, the need for and means of providing adequate project scope definition prior to start of design, and the lack of a rational, analytic review policy in the Corps.

In September, 1985, the Corps of Engineers South Atlantic Division sponsored a forum on design quality. The meeting was attended by members of the Division as well as representatives from numerous private A/E firms routinely involved in the design of Corps projects. The forum was called in response to the perception that design quality

within the Savannah District had diminished. The purpose was to obtain A/E opinions as to the significant things that adversely affect the quality of the product they provide to the Savannah District. The results of the forum were published in minutes dated 3 September 1985. (10) The views expressed by the A/E participants in many ways parallel observations made during data collection for this study. Specific problems included inadequately defined project scopes, lack of a first rate effort on design reviews, lack of A/E involvement in field work, failure on the part of the District to coordinate and edit review comments before turning them over to designers, and a lack of continuity in review when different individuals review projects at each design stage. Numerous other issues were discussed as well. These minutes provide insight as to the perception of the Corps held by the private engineering community and how that perception is affected by Corps practices. Although the forum only involved the South Atlantic Division, it is not unrealistic to expect A/E firms contracted by other districts to hold similar opinions under similar circumstances. Hence, the results of that forum have Corps wide applicability.

Studies from Academic Institutions:

Four master's theses were found that addressed the issue of contract modifications in federal construction. The first was written by Henry J. Turowski at the Naval Postgraduate School in Monterey and titled "Contractor Quality Control". (11) The thesis examined the government's contractor quality control (CQC) program. Its purpose was to research the attitudes of individuals directly involved in the CQC

process. Only the chapter on alternatives to the CQC program directly related to the issues of modifications and design reviews. Turowski discussed using good design reviews as a means of improving construction quality. The study recommends separate design review teams, a conclusion which corresponds to that of this paper. The study also calls for increased designer responsibility and involvement in the construction process once a project begins. Turowski's paper only devotes a few pages to topics related to this study. However, the information in those pages relating to design reviews are in keeping with the findings of this study and will be discussed further in Chapter 6.

Henry J. Rowland completed his thesis on "The Causes and Effects of Change Orders on the Construction Process" while a student at the Georgia Institute of Technology in November 1981. (12) The objective of his study was to highlight complications which relate to legal disputes in construction. A secondary objective was to quantify the causes and effects of contract change orders. The data for this second objective was collected from projects administered by the Southern Division of the Naval Facilities Engineering Command. In several ways, however, the study is disappointing. The causes for each of the types of modifications are not identified. The author deliberately selected projects for study which had many modifications; consequently, it is not possible to calculate a meaningful "average" number of mods per project. Cost growth is not discussed at all. Finally, it is the opinion of this author that the paper failed to meet the objective implied in the title. Instead of defining the causes and

effects of change orders, he develops general "rules of thumb" for construction projects. But, since his data base consists of only "problem" projects, the general applicability of these rules is suspect. Regardless of these shortcomings, much of the raw data Rowland collected on construction and modification costs was able to be processed using the methodology of this study. This, in turn, allowed for an "apples-to-apples" comparison between the two studies. The purpose of James R. Rosmond's work on "Analysis of Low Bidding and Change Order Rates for Navy Facilities Construction Contracts" is to evaluate what effects bidders of fixed price contracts (government construction) have on contract prices when the level of bidding intensity increases. (13) His basic thesis is that in environments of intense competition, contractors are willing to assume more risk in preparing estimates in order to be awarded contracts. The contractor may then attempt to improve his financial position by the use of change orders after construction begins. Rosmond draws his data from a sample of projects administered by the Western Division of the U.S. Naval Facilities Engineering Command. He provides a good discussion on the sources of modifications and on the use of "change order rates" (cost growth) to assess contractor performance.

The last study was an "Examination of the Constructibility Review in Government Contracting" by Lloyd S. Finley, Purdue University, August 1984. (14) The purpose of his study was to examine the constructibility review process in construction projects administered by the Navy. Finley presents data collected from two constructibility reviews, calculates the direct and indirect costs of

the reviews, and then determines the benefits derived by calculating what the items identified during the review would have cost had they been left in the contract and later modified. Finley makes an excellent case for the cost effectiveness of constructibility reviews. For one project, the benefit-cost ratio for the review was 2.8 to 1. For the other, it was 28.4 to 1. He further makes the point that reducing mods by review improves the overall contract management effort by improving the productivity of the contract administrators. He also supports the use of review checklists to provide consistency. His methodology is excellent, and could be used to evaluate the effectiveness of constructibility reviews anywhere. A major shortcoming, however, is in the limited data base. He uses the data from two projects to draw rather sweeping conclusions about the value of constructibility reviews.

Articles from Professional Journals and Magazines:

Journal and magazine abstracts were reviewed for the period 1970-1985 for articles related to the subject of construction contract modifications. One was found in The Military Engineer, one in Engineer News Record, one in Civil Engineering, and two in journals of the proceedings of the American Society of Civil Engineers (ASCE). An additional article was found on a standardized review checklist in a reprint of an article first appearing in the DPIC Communique.

The article in The Military Engineer was titled "Productivity Improvement" by Dennis L. Ballou. (15) The author stated that one of the detractors from good productivity is contract disputes. He claimed

reducing time to settle disputes and avoiding litigation is essential to increasing productivity. Sources of disputes were listed as imprecise specification language, ambiguous drawings, unknown site conditions, and owner-initiated changes. The author did not address eliminating the sources of disputes. Although not dealing directly with modifications, much of what the author says about the relationship between disputes and productivity is applicable to modification processing. The article provides good background material, even though not directly related to the subject of this paper.

Engineer News-Record ran a very short article titled "Design Changes: The Largest Cause of Overruns" in March 1975. (16) The article cited an unnamed Government Accounting Office report which studied 269 federal projects, most of them construction, that experienced cost overruns. The information provided on the study was very sketchy. Of interest to this study was the fact that 41% of cost overruns were found to be caused by design changes. 59 projects had cost overruns of 100% or more; 47 of these were administered by the Corps of Engineers. Since the study upon which the article was based was not identified and therefore could not be reviewed in detail, the applicability of the limited information contained in the article was limited.

The "Forum" section of Civil Engineering magazine published the comments Walter P. Moore delivered at a keynote address to the 1984 annual meeting of the American Concrete Institute. (17) Titled "Structural Safety: The Profession at a Crossroads", the article provided an excellent discussion as to why civilian engineer firms no

longer have time to perform thorough reviews or visit project sites. The author claims the prime reason for this is the increased "fast tracking" of projects to save time and the reluctance of owners to budget the necessary time and money for reviews. He further blames the shift of supervisory responsibility from the architect to the project owner. The applicability of this article to federal projects lies in the fact that much federal design is done by civilian Architect/Engineer (A/E) firms that are operating under similar time and budget constraints. Although not directly related to this study, Moore's comments provide insight into some of the problems within the private engineering community. They provide an interesting supplement to the views expressed during the Design Quality Forum.

Harvey Kagan's article "How Designers Can Avoid Construction Claims", Journal of Professional Issues in Engineering of the ASCE provides more information of direct interest to the study of mods. (18) Kagan divides his article into a discussion of contract documents and shop drawings. In his discussion of contract documents, he notes that mods are often the result of standard contracts (such as those use by the Corps). He claims that designers often do not read the clauses of these "off-the-shelf" contracts. The result is contracts containing conflicting clauses which leads to later claims. He emphasizes the need for good reviews to resolve these problems early in the design cycle.

"Construction Claims: Frequency and Severity" was written by James E. Diekmann and Mark C. Nelson and published the results of a study they completed at the University of Colorado, Boulder. (19) Data

on mod causes, sources, costs, and cost growth of 22 federally administered projects involving 427 claims and modifications was presented. The Diekmann-Nelson study found design deficiencies to be the most frequent cause of construction claims. They further studied the impact of project size and design agency on modifications. Their approach was very similar to the methodology employed here and provided an excellent reference for comparing their results with those of this study.

One of the issues raised during this study was the use of review checklists to assist in the review process. Checklists can be an aid to design reviewers in conducting their reviews. There is a problem, however, in designing such a checklist that is flexible enough to cover the myriad projects the Corps administers yet is detailed enough to be of any use. One such checklist developed to meet these criteria is "Redicheck". In an article written for the Design Professionals Insurance Company Communique April 1984 issue, William Nigro described what "Redicheck" was and what it could do.(20) He describes "Redicheck" as "a structured review system which provides a logical and orderly approach to checking construction drawings." The system is designed to be used in the later stages of design to assist in coordinating drawings with written specifications and comparing drawings dealing with one design discipline with those of another. It is not a technical review, and is not intended for use as a document review within any one discipline. The author goes on to provide guidance on how the system should be used. "Redicheck" was favorably referred to in two of the other papers surveyed for this study. Hence,

it may be a system the Corps should investigate for use on their construction projects.

SUMMARY:

This chapter provided an overview of existing papers, articles, studies, and reports completed over the past 15 years and relating to the research objectives of this study. Whereas numerous authors have addressed some aspect of construction contracting, relatively few have specifically targeted the issues examined in this study. Consequently, this study has the potential to make a significant contribution by not only adding to the existing data base on mod causes and costs but also by tying together the findings of these various other studies.

Endnotes, Chapter 2

1. U.S. Army Engineer Pamphlet (EP) 415-1-2, Modifications and Claims Guide, (Washington D.C.: Office of the Chief of Engineers, 1 October 1976), page 1-1.
2. Office of the Chief of Engineers, Construction Contract Negotiating Guide, (Washington D.C.: Office of the Chief of Engineers, FY 77 Edition).
3. District Regulation 415-2-1, Resident Engineers Manual, (1 August 1978), page 1-1.
4. USA-CERL, "Ways to Improve Construction Contract Modification Processing: USAFEA Korea Case Study", (CERL Technical Report P-85/11, May 1985).
5. USA-CERL, "Automated Review Management System", Users Manual, 3 May 1985.
6. Corps of Engineers Report of the Blue Ribbon Panel on "Management of Construction Quality in the U.S. Army Corps of Engineers", (Office of the Chief of Engineers, March 1983).
7. Corps of Engineers Report of the Green Ribbon Panel on "U.S. Army Corps of Engineers Support to Army Installation Commanders", (Office of the Chief of Engineers, March 1985).
8. Texas A&M Research Foundation, "A Systems Approach to Design and Construction for the Corps of Engineers", (TR 68-041, College Station, Texas, May 1968).
9. Texas A & M Research Foundation, "Systems Analysis of Corps A/E Design Engineering", (College Station, Texas, June 1969).
10. Corps of Engineers South Atlantic Division, "Minutes of the Design Quality Forum", (Savannah District, 3 September 1985).
11. Henry J. Turowski, "Contractor Quality Control", (Master's thesis, Naval Postgraduate School, Monterrey, December 1980).
12. Henry J. Rowland, "The Causes and Effects of Change Orders on the Construction Process", (Master's thesis, Georgia Institute of Technology, School of Civil Engineering, November 1981).

13. James R. Rosmond, "Analysis of Low Bidding and Change Order Rates for Navy Facilities Construction Contracts", (Master's thesis, Naval Postgraduate School, Monterey, June 1984).
14. Lloyd S. Finley, "Examination of the Constructability [sic] Review in Government Contracting", (Master's thesis, Purdue University, School of Civil Engineering, 3 August 1984).
15. Dennis L. Ballou, "Productivity Improvement", The Military Engineer, (Vol. 77, Sept-Oct 1985), page 484. Ballou is the Assistant General Manager for Transit System Development at the Metropolitan Atlantic Rapid Transit Authority.
16. "Design Changes: The Largest Cause of Overruns", Engineer News Record, (6 March 1975), page 10.
17. Walter P. Moore, "Structural Safety: The Profession at a Crossroads", Civil Engineering, (July 1985), pages 7-8. Excerpted from ACI's Concrete International, October 1984. Moore is president of the Houston based structural, civil, and traffic engineering firm of Walter P. Moore and Associates.
18. Harvey A. Kagan, "How Designers Can Avoid Construction Claims", Journal of Professional Issues in Engineering, Proceedings of the American Society of Civil Engineers, (Vol. 111, No. 3, July 1985), page 100. Kagan is a professor of Civil Engineering at Rutgers University.
19. James E. Diekmann and Mark C. Nelson, "Construction Claims: Frequency and Severity", Journal of Construction Engineering and Management, Proceedings of the American Society of Civil Engineers, (Vol. 111, No. 1, March 1985), page 74.
20. William T. Nigro, "Redicheck: A System of Interdisciplinary Coordination", DPIC Communique, (Design Professionals Insurance Company, April 1984), pages 1-4.

CHAPTER 3

METHODOLOGY

General:

This chapter details the methods and procedures used during the conduct of the study. All project data was obtained from primary sources, such as contract documents, project correspondence, standard administrative forms, questionnaires, and discussions with individuals involved with modification processing. Secondary sources were used in the review of previous studies and writings as discussed in Chapter 2.

Both completed and ongoing projects were selected for study. Projects were selected from an arbitrarily chosen window of 18 months running from 1 January 1984 through 30 June 1985. Specific criteria for project selection were:

1. All projects were to be located on the supported installation.
2. Completed projects must have been finished after 1 January 1984.
3. Ongoing projects may have started at any time prior to 30 June 1985 providing a minimum of six months (as of 30 June) passed since issuance of the notice to proceed OR the project was scheduled for a minimum of 50% completion as of 30 June 1985.
4. Plans, specifications, and project files for all projects had to be available at the Resident Engineer Office.

The purpose of these criteria was to insure all projects selected would be substantially complete by the time this paper was to be completed and to insure project files would be readily available.

A total of 25 projects were selected based on this criteria. These projects are identified throughout this paper by a project number (1 through 25). Each project number was assigned based on project start date. The earlier the project was started, the lower the number assigned.

These 25 projects represented a mix of five MCA, 15 OMA, and five AFH funded projects and consisted of a total of 268 modifications. These mods included 778 individual items of change. Project award amounts ranged from \$71,000 to \$8,000,000. All but three projects were completed as of the date of this paper. As stated in the assumptions in Chapter 1, these three projects were considered substantially complete enough to be included in the study.

There were three other projects, however, which contain modification costs of such magnitude that they distorted the findings. These projects were:

Project 5: Project 5 contained a \$260,194 mod to remove asbestos insulation.

Project 15: This contract was issued with a poorly defined scope in an hurried attempt to take advantage of year-end funds. The project underwent three scope revisions, with associated modifications, after work began. Project cost growth totaled \$477,408 (89%). 40% of the increase was due to user requested changes; 39% due to site conditions.

Project 22: Project 22 replaced central heating and air conditioning in family housing units. After the contract was awarded,

a design criteria change was issued concerning ductwork installation. This change cost \$319,250.

Combined, these account for over 44% of the modification cost for all 25 projects and have a disproportionate impact on the overall results. Consequently, unless otherwise noted, the high cost mods and Project 15 were deleted from calculations in the remainder of this study.

The study was organized into three phases, each of which is the basis for one of the three following chapters. The titles of these phases are:

1. The Causes and Costs of Modifications.
2. The Preconstruction Design Review System.
3. Comparison of Findings with Previous Studies.

Each involved a different research methodology. Mod causes and costs were determined by studying information contained in project files and contract documents. Data on the review system was collected by a questionnaire distributed to District personnel involved with military construction. The comparison of findings used a descriptive methodology to contrast results of related studies to the findings of this study. Each methodology is described in detail in the sections which follow.

Methodology for Determining the Causes and Costs of Modifications:

Once negotiated and agreed to by the parties concerned, modifications become part of the construction contract. Consequently,

the terms of each mod were usually well documented. Most of the data collected in this segment of the study came from reviewing project files. Primary information sources were ENG Forms 3938 and 3938-B (Contract Modification Proposal and Acceptance), Standard Form 30 (Amendment of Solicitation/Modification of Contract), memorandums for record, contractor proposals, shop drawings, and other documents or correspondence relating to each project studied.

ENG Form 3938 (Figure 1) was used for modifications within the approval authority of the resident contracting officer. On this form were recorded the details of the changes to be made, the total cost of the changes, and any changes in contract time negotiated with the contractor. This form was designed to be a bilateral contract agreement and is signed by both the contractor and the resident contracting officer. It then becomes part of the contract. ENG Form 3938-B (Figure 2) was used to supplement the information contained in Form 3938. The 3938-B was used to record the reason(s) why the change was necessary and provided a brief summary of the negotiations between the contractor and the government. Standard Form (SF) 30 (Figure 3) was used for modifications outside the approval authority of the resident contracting officer. The information contained was similar to that of Form 3938. The SF 30, however, was signed by the contracting officer instead of the resident contracting officer. These forms were maintained for each modification to each project. Consequently, excellent primary sources were available to identify individual changes and their corresponding cost.

CONTRACT MODIFICATION PROPOSAL AND ACCEPTANCE

CONTRACTING OFFICER'S COPY

12. PROJECT [REDACTED]	13. CONTRACT NO. [REDACTED]	14. MODIFICATION NO. P00001
15. FUNDS PROGRAMMED FOR THIS CHANGE IN THE AMOUNT OF \$1,588.00 Increase		
16. NECESSITY FOR CHANGE AND REASON FOR OMISSION FROM PLANS AND SPECIFICATIONS <u>Necessity for Change:</u> Existing manhole is dilapidated. <u>Reason for Omission from Plans and Specifications:</u> Physical condition of manhole was not known until after construction commenced.		
17. RESUME OF NEGOTIATIONS OR RECOMMENDATIONS (Government Representative) <u>Negotiating Representatives:</u> Government: [REDACTED] Contractor: [REDACTED] The condition of the manhole was found during the first part of May 1984. The Contractor was verbally requested to submit a proposal to replace it. The Contractor submitted his proposal on May 18 1984 in the amount of \$3,246.00 with no days requirement for a Time Extension. Since the Contractor's price proposal was less than \$25,000 and the price breakdown was in sufficient detail to disclose the element of cost, it was decided to use the price breakdown to determine an equitable adjustment as permitted by DCI-1-372(a). The price breakdown was reviewed by [REDACTED] on 23 May 1984. The review revealed that the Contractor was pricing the replacement of two (2) manholes. On 23 May 1984 this was discussed with the Contractor and he was offered \$1,588.00 to replace the one (1) manhole. The other manhole has deteriorated but is considered to be usable. On 31 May 1984 the Contractor accepted the offer. In my judgement the negotiated price is considered equitable and reasonable. Extension in Contract time is not warranted as a result of this modification.		
DATE 4 Jun 84	TYPED NAME AND TITLE OF GOVERNMENT REPRESENTATIVE [REDACTED] Resident Contracting Officer	SIGNATURE [REDACTED]

ENG Form 3938-B
APR 1987

U.S. GOVERNMENT PRINTING OFFICE: 1982-300-251

FIGURE 2
Sample ENG Form 3938-B

AMENDMENT OF SOLICITATION / MODIFICATION OF CONTRACT		CONTRACT ID CODE J	PAGE OF PAGES 1 2
1. AMENDMENT/MODIFICATION NO. PO0014		3. EFFECTIVE DATE See Block 16c	4. REQUISITION/PURCHASE REG. NO.
5. PROJECT NO. (if applicable)			
6. ISSUED BY U.S. Army Corps of Engineers District	CODE W58VUW	7. AMENDMENT CODE (if other than item 6)	CODE
8. NAME AND ADDRESS OF CONTRACTOR (No., street, country, State and ZIP Code) Final Distribution ECDO RECORD CONTRACT FILE		9A. AMENDMENT OF SOLICITATION NO. 9B. DATED (SEE ITEM 11) 10A. MODIFICATION OF CONTRACT/ORDER NO. 10B. DATED (SEE ITEM 13) 83 Sep 30	
9. FACILITY CODE			
11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS			
<input type="checkbox"/> The above numbered solicitation is amended as set forth in item 14. The hour and date specified for receipt of Offers <input type="checkbox"/> is extended <input type="checkbox"/> is not extended. Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods: (a) By completing items 8 and 15, and returning _____ copies of the amendment. (b) By acknowledging receipt of this amendment on each copy of the offer submitted. (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.			
12. ACCOUNTING AND APPROPRIATION DATA (if required) 2152050 508-9725 P6700-3200 S23028 W/O 85-11 RJ5003501182004 \$42,462.00			
13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14. PREVIOUS			
(A) THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CON- TRACT ORDER NO. IN ITEM 10A. 5/23/85 <input checked="" type="checkbox"/> Clause J, "Changes," of the Contract General Provisions (B) THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(D). (C) THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: (D) OTHER (Specify type of modification and authority):			
E. IMPORTANT Contractor <input type="checkbox"/> is not, <input checked="" type="checkbox"/> requested to sign to sign this document and return <u>one</u> copy to the issuing office to the issuing office.			
14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible):			
a. Change: Provide all labor, material and equipment to perform the specific items of work, in the basement and other areas of XXXXXXXXXX in accordance with Sheets 1 thru 7 provided and revised by Request for Proposal SXO20 dated 30 May 1985, as hereafter listed: (1) Demolition; Remove existing wood framing in the basement not suitable for reuse, as directed by my field representative. (2) Complete all rough-in framing for additional partitions in the basement as shown on Sheet 5 referenced above.			
(continued)			
Except as provided herein, all terms and conditions of the document referenced in item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.			
15A. NAME AND TITLE OF SIGNER (Type or print) Major, Corps of Engineers		16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print) Major, Corps of Engineers	
15B. CONTRACTOR/OFFEROR (Signature of person authorized to sign)	15C. DATE SIGNED 11 JUL 85	16B. UNITED STATES OF AMERICA BY: (Signature of Contracting Officer)	16C. DATE SIGNED 08 JUL 1985

NSN 7540-01-152-8078
PREVIOUS EDITION UNUSABLE

30-105

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA

FIGURE 3
Sample Standard Form 30

Six causes of mods were identified. Each item of change was classified under one of these six categories based on a subjective evaluation of the nature of each change item using the criteria defined below. These groupings evolved as each mod was reviewed; they were not arbitrarily identified beforehand. The six sources of mods identified in this study were:

1. Design deficiency.
2. Unknown site conditions.
3. User requested changes.
4. "No fault" design changes.
5. Value engineering.
6. Other.

Items were classified as "design deficiencies" if it were clear the change was due to faulty design or other errors/omissions on the part of the designer. For those instances where it was not clear if the change was due to a failure on the part of the designer, the benefit of the doubt went to the designer and the item was placed under one of the other categories. Consequently, this category was deliberately designed to err on the side of conservatism. "Unknown site conditions" was used for changes resulting from site conditions encountered during construction different than those expected. This included underground conditions such as unrecorded utility lines, soil conditions, or bedrock. It also included situations where improvements to existing buildings had been made over the years and not properly documented. This was a particular problem for the projects of this study since many involved renovation of existing buildings, some of

which were almost 100 years old. "User requested changes" were those changes initiated by the individual or agency that would ultimately use the facility. "No fault design changes" included changes to building codes, changes to military regulations which impacted on design, or other situations where events outside the control of the District, contractor, or user. "Value engineering" changes were those resulting from the Corps of Engineers value engineering program. Under this program, a contractor can share in the savings the government realizes if the contractor discovers a less expensive method of completing the work designed. The "other" category was used for time extensions due to poor weather, administrative changes to contract wording, problems with site accessibility, problems caused by user interference with work crews, or other items occurring too rarely to qualify for a category of their own and not readily classified under one of the other headings.

"Design deficiencies" were further analyzed to determine in which engineering design discipline deficiencies occurred. All changes due to design deficiencies were classified as being "architectural", "civil", "mechanical", "electrical", "structural", or "administrative". Thus, a basis for further examination of the problem of design deficiencies was established. This technique also provides a basis for the focus of design review effort.

Analyzing the causes of change was done in two ways. The first analysis was by "items of change". The purpose of this "item of change" analysis was to identify the total number of changes and their causes. Every mod may consist of one or more individual changes to the contract. Multiple changes are often combined under one contract

modification to expedite administrative requirements. Changes within the same mod may have different sources. For example, a modification containing seven changes may have three due to design deficiencies, two due to site conditions, and two due to user requests. All change items were treated equally, regardless of cost. For example, a design deficiency costing \$10,000 was considered one item of change; a no-cost administrative change in contract wording was also considered one item of change. This analysis resulted in an accurate assessment of the causes of contract changes to the projects studied.

The second analysis was by cost. The purpose of this analysis was to determine which modification sources cost the government the greatest amount of money and to determine the overall direct costs associated with mods. Only direct costs, as charged by the contractor, were considered in this analysis. Recall that ENG Form 3938 only contains the total mod cost: it does not record the cost of each item of change. Consequently, the cost per change for mods containing multiple items of change had to be obtained from contractor proposals (Figure 4). These proposals were submitted by the contractor when the need for a change was first identified. This proposal was then negotiated bilaterally with the government's representative and a final mod price established. The corrected estimate was filed with the contract documents. This combination of cost and "item of change" analyses provided a comprehensive evaluation of contract mod causes.

2. ISSUING OFFICE XXXXXXXXXX		9. CONTRACT XXXXXXXXXX	10. MODIFICATION NO. SX001
11. CONTRACTOR'S PROPOSAL—CHANGE IN CONTRACT PRICE <small>(Detailed breakdown, attach additional sheets as necessary)</small>			
NOTE: SIGN AND RETURN ORIGINAL AND COPIES: RETAIN ONE COPY FOR YOUR FILE			
NET INCREASE \$ 326,761.38	NET DECREASE \$	CALENDAR DAYS INCREASE 268 DAYS	
(Proposed) PROPOSED CHANGE BLDG. 66		PROPOSED CHANGE BLDG. 67	
Material: Sheet Metal \$ 586.74 Insulation 304.59 Venting 79.59 Relocate Flue 19.43 Registers - Grilles 277.00 Electrical 9.69 87% Furnace 60.00 2 x 4 Bracing 18.00 Water Piping 8.04 Material Total \$1,363.08		Material: Sheet Metal \$ 551.36 Insulation 228.38 Venting 240.44 Register - Grilles 216.00 Electrical 29.55 87% Furnace 60.00 Water Piping 8.04 Material Total \$1,333.77	
Labor: Sheet Metal Worker 127 Hrs. @ \$11.00/Hr. \$1,452.00 Insulation Installer 62 Hrs. @ \$14.00/Hr. 868.00 Pipe Fitter 4 Hrs. @ \$12.11/Hr. 48.44 Electrician 5 Hrs. @ \$9.06/Hr. 45.30 Painter 2 Hrs. @ \$13.54/Hr. 27.18 Carpenter 3 Hrs. @ \$11.53/Hr. 34.59 Labor Total \$2,420.51		Labor: Sheet Metal Worker 59 Hrs. @ \$11.00/Hr. \$ 649.00 Insulation Installer 44 Hrs. @ \$14.00/Hr. 616.00 Pipe Fitter 1 Hr. @ \$12.11/Hr. 12.11 Electrician 2 Hrs. @ \$9.06/Hr. 18.12 Painter 2 Hrs. @ \$13.59/Hr. 27.18 Labor Total \$1,322.41	
Payroll & Benefits Burden: 38.7% \$ 936.73 SUBTOTAL \$4,720.32		Payroll & Benefits Burden: 38.7% \$ 511.77 SUBTOTAL \$2,661.29	
Overhead: 15.26% \$ 720.32 SUBTOTAL \$5,440.64		Overhead: 15.26% \$ 406.11 SUBTOTAL \$3,067.40	
Profit: 10% \$ 544.06 TOTAL COST PER UNIT \$6,330.81		Profit: 10% \$ 306.74 TOTAL COST PER UNIT \$3,374.14	
TOTAL COST 22 UNITS \$131,633.40		TOTAL COST 30 UNITS \$101,224.20	
Estimating Labor 87 Hr. \$13.75/Hr. \$1,196.25 Payroll Burden 38.7% 462.44 SUBTOTAL \$1,659.19 Overhead 15.26 % 253.19 TOTAL \$1,912.38			
DATE 5/8/85	TYPED NAME AND TITLE XXXXXXXXXX /V.P. Project Manager		SIGNATURE XXXXXXXXXX

ENG FORM 3938
APR 87

PAGE 2 OF 2 PAGES

FIGURE 4
Sample Contractor's Proposal

The main statistic used to measure mod cost in this study was project cost growth. There is, however, no single method of calculating cost growth within the Corps of Engineers. For the purposes of this study, cost growth was calculated from direct mod costs. Cost growth was expressed as a percentage and reflected how much a project exceeded the original contract amount. This was calculated by first adjusting the contract award amount in the following manner:

$$\begin{aligned} \text{Adjusted Contract Amount} &= (\text{Award Amount}) + (\text{Supplemental Agreements}) \\ &\quad - (\text{Work Deletions or Terminations}) \end{aligned}$$

Supplemental agreements, work deletions, and terminations all reflect changes to project scope. In several cases, these represented extremely large values. Consequently, failure to adjust the original contract amount to allow for scope changes resulted in an inaccurate cost growth figure. After calculating the adjusted contract amount, cost growth was found in the following manner:

$$\text{Cost Growth} = (\text{Net Mod Cost}) / (\text{Adjusted Contract Amount})$$

The use of cost growth figures provided a convenient, standard basis of comparison between different projects.

Projects were also analyzed on the basis of project size, project type, agency responsible for design, and predesign reviews to

determine if any correlation existed between these factors and mod sources or costs. Project sizes were classified based on adjusted contract amount. The classifications used were "less than \$500,000", "\$500,000-\$1,000,000", and "over \$1,000,000". These size intervals were selected to match the intervals used in other studies to facilitate comparison of findings. Classification by project type involved grouping projects by funding source: Operations and Maintenance, Army (OMA), Army Family Housing (AFH), and Military Construction, Army (MCA). Classification by designer involved identifying which projects were designed by contracted, private A/E firms and which were designed by in-house, government employed engineers. These government engineers worked for either the District or the installation's Directorate of Engineering and Housing (DEH). Each of these agencies had the option of designing projects using their own in-house resources or contracting the design out to civilian architecture or engineering (A/E) firms. Each of these three items was very objective in nature and allowed each project to be easily classified.

Classification under the fourth factor, predesign review, was more subjective. The Corps recognizes five types of predesign reviews. These are:

Constructibility Reviews. Conducted to insure a project can be built as designed.

Technical Reviews. Conducted to insure design meets all applicable codes and technical specifications.

Using Service Reviews. Conducted by the user in the early stages of design to insure the design meets the needs of those who are to use the finished facility.

Biddability Reviews. Conducted to insure sufficient information is provided to the contractor to allow a bid to be submitted.

Operability Reviews. Conducted to insure that, once the project is completed, the design allows for ease in maintainability and operability.

Of these, only the first two were considered in detail for this study for the following reasons. Using service reviews were not evaluated because those reviews are normally conducted by the installation DEH. Since the District has minimum control over these reviews, they were not included in this analysis. Second, the supporting District did not conduct separate biddability and operability reviews at the time this study was conducted. Those items pertaining to operability and biddability were checked as part of either the constructibility or technical review. Consequently, the only reviews evaluated were technical and constructibility reviews conducted within the District.

One study objective was to determine if failure to conduct any or all of the first three reviews listed above resulted in a noticeable change in project cost. Since records on reviews were not routinely kept once a project was complete, this was accomplished by interviews with individuals familiar with each project in the District or DEH. There were often differing perspectives on what reviews took place and on the detail with which it was conducted. For the purposes of this study, if anyone in any of the contacted agencies attested to a review having taken place for a particular project, that project was classified as having been given that review. Reviews were considered on a "yes" or "no" basis only; no attempt was made at this point to

establish the quality or depth of the review conducted. Evaluation of the review process was done in a separate phase of the study and will be discussed in the following section.

Modification costs may be measured by ways other than just direct cost. Negotiation, design, administration, and processing activities all consume manhours the government must pay for. This study was to quantify the dollar amount of this overhead and to determine how the effort expended on mods impacted on overall productivity. In this District, the personnel responsible for mods were the same people responsible for new project design, construction supervision, and quality assurance. Consequently, any time spent on modifications is time not spent on these other tasks. Therefore, if the time spent on mods could be reduced, overall District productivity would be increased.

The District maintained a cost account of engineering, design, and overhead for modifications to each project beginning at the time the contract was awarded. Cost amounts were available from periodic reports prepared and maintained in the contract administration branch within Construction Division. Costs for engineering and design were maintained separately from overhead. However, these amounts related only to costs incurred by Engineering Division. They did not reflect the costs incurred by Construction Division in negotiations, site investigations, administrative processing, etc. Such costs were accounted for under a general "construction" account which combined all project construction related costs together. Individual modification costs were included in this cumulative total and could not therefore

be established. Consequently, the amounts presented for overhead are conservative in that they reflect only Engineering Division's administrative costs. They do not include costs credited to the construction account.

Within the District, engineering, design, and overhead costs were accounted for by project, not by individual modification. The amounts were analyzed by taking project overhead figures and determining the average cost per mod and the average cost per item of change. These figures were then statistically analyzed to determine the mean, mode, and range on both a "per mod" and "per item of change" basis.

The impact of mod processing on productivity was determined by a one of the questions in the questionnaire prepared to evaluate the design review system. The questionnaire is discussed in detail in the following section. This particular question listed the activities, to include modifications, that each individual could be expected to be involved in on any given day. The question asked the respondent to identify how much time during a typical week was spent on each activity. Responses were set on a multiple choice format, with each choice representing a range of percentages. (See question #9, Appendix 6.) The intervals were arbitrarily selected at 0%, 1%-5%, 6%-10%, 11%-20%, 21%-30%, 31%-50%, and over 50%. The resulting information was analyzed by taking all responses from a particular office and converting the individual responses to hours out of a 40 hour week. For example, if one individual answered that he spent 6%-10% of his time on mods, that was converted to a window of 2.4 - 4.0 hours per 40

hour week. The lower and upper figures of this window were summed for all respondents from the same office. These summations were converted back into percentages by dividing each by the total number of available manhours. The following example illustrates how this was done for a hypothetical office with four people providing responses:

TABLE 3
Time Spent on Modifications (Example)

Respondent	Answer Given on Questionnaire	Range in Hours		Total Hours in Week
		Lower	Upper	
#1	6%-10%	2.4	4.0	40
#2	11%-20%	4.4	8.0	40
#3	1%- 5%	0.4	2.0	40
#4	6%-10%	2.4	4.0	40
Sums:		9.6	18.0	160

By dividing the summed lower (9.6) and upper (18.0) ranges of hours each by the total available manhours (160), it is estimated that this office spends between 6% and 11% of its available manhours on modifications. This calculation was performed individually for each office involved with mod processing or design and gave an indication of the total time modifications consumed within the District.

All computations were performed on a Texas Instruments Professional Computer using Lotus 1-2-3 spreadsheet software. Tables of data are inclosed in the appendices. Lotus 1-2-3 was also used to develop graphs and charts for data presentation. These figures are presented, where appropriate, in Chapters 4 and 5.

In summary, data on mod causes, costs, and sources of design deficiencies were collected from primary source documents, including

construction files, cost reports, a questionnaire, and individual discussions. Mod costs were analyzed from the perspectives of direct dollar cost, indirect cost, and the diversion of manhours away from other essential tasks. This methodology, consisting as it did of analysis by both cost and items of change, provided a comprehensive assessment of the cost and causes of contract changes.

Methodology for Evaluating the Design Review System:

The data collected under the foregoing methodology led to the conclusion that the primary causes of modifications on the projects studied were design deficiencies, user requested changes, and unknown site conditions. The discovery of this fact led to an analysis of the design review system used by the supporting District. Detailed, thorough design reviews are a major factor in insuring design problems are identified and corrected before construction begins. The fact that so many design deficiencies were identified indicated possible problems with this system. Consequently, it was decided to evaluate the review system to determine where those problems might lie.

Information for the evaluation was collected by questionnaire. The purpose of the questionnaire was to obtain data from which to evaluate the preconstruction review process within the District. The objective was to solicit the opinions of those personnel involved in the review system, both at the supervisory and "worker" levels.

The evaluation was based on an analysis of three primary components of the review system: personnel qualifications, time available, and system organization and procedures. Specific items of

interest were identified within each of these components. Opinions on each item were obtained by individual questions. A total of 43 questions were asked. Most items were covered by multiple questions asking for the same information but in a slightly different manner. This redundancy was used to insure a reliable representation of the respondents opinion on each item was obtained. Redundant questions were separated within the questionnaire. A summary of the items within each component and the specific questions addressing each item is shown in Table 4. A copy of the questionnaire, with a summary of responses, is at Appendix 6.

The questionnaire was validated by distributing six copies to District employees to insure questions were clearly worded and understood by recipients. The questionnaire was then modified and distributed to a representative sample selected from those offices within the District involved with the conduct of military construction reviews. 71 questionnaires were originally distributed. Of these, 15 of the respondents were subsequently found to have no direct involvement with reviews. Their questionnaires were discarded. Representation from Engineering and Construction Divisions as contained in the remaining 56 questionnaires was as shown in Table 5. Table 6 presents a further breakdown of the respondents from Engineering Division. Population statistics were taken from the District's organization chart. Population figures included all authorized engineers, architects, and other professional personnel (such as geologists) and engineer technicians. Temporary hire, draftsmen, and clerical personnel were not included.

TABLE 4
Review System Components of Evaluation

Component	Items of Interest	Specific Questions Applying to Each Item of Interest
Personnel		
Qualifications	Education	#40
	Training/Expertise	#4,5,22
	Practical Experience	#35,36,37,38,39
	Professional Licensing	#41,42,43
	Attitude Toward Reviews	#16,17,26
Time Available	Priority of Work	#10,15,27
	Time Required vs Time Available	#6,7,8,14
System Organization and Procedures	Site Visits	#11,12,28,29
	Incorporation of Comments into Design	#18,19,31
	Review Checklists	#21,33
	Review Quality	#34
	Continuity, Feedback and Flow of Info	#25,30,32
	Frequency of Reviews	#23,24
	Estimate Accuracy	#20 (Note)
	Familiarity with Regulations	#13 (Note)
Admin Data	Branch and Office	#1

Note: Analysis showed problems in the interpretation of questions 13 and 20. Consequently, the responses were not evaluated.

TABLE 5
Summary of Survey Population Sample - Both Divisions

Engineering Division			Construction Division		
	Engr Div	Project Managers	Constr Reps	Resdnt Off	CD-1
Sample:	29	10	6	5	6
Population:	88	23	10	9	7
% of Pop:	27% (42%)	43%	60%	56%	86%

TABLE 6
Representation From Engineering Division

Branch and Section	Sample	Population	Sample as % of Population
Design Branch:			
Mech/Elec	7	15	47%
Gen Struct	4	10	40%
Arch	7	9	78%
Est/Specs	6	19	32%
Res Struct	3	11	27%
Fndtns/Mtrls Branch:			
Local Protection	1	12	8%
Geology	1	12	8%
Totals:	29	88	27%
Less Fndns/Mtrl Br:	27	64	42%

Responses were analyzed by response group. The purpose of classifying responses by response group was to determine differences in perceptions of the various issues being examined. Five response groups were identified; two from Engineering Division and three from Construction Division. Engineering groups consisted of project managers and engineers in other branches involved in reviews. Construction Division groups included construction field representatives working on installation projects, personnel from quality assurance branch, and office engineers and technicians from the resident office.

A respondent profile by job area is presented in Table 7. Slightly over 50% came from Engineering Division, the agency responsible for design and technical review. 30% were construction representatives, resident office personnel, and personnel from quality assurance branch. These individuals all fall under the Construction

Division, and share responsibility for constructibility reviews. Project managers comprised the remaining 18%.

TABLE 7
Respondent Profile (Question 1)

Office, Branch or Job Description	Percentage Respondents
Engineering Division	51.8%
Project Managers	17.9%
Quality Assurance	10.7%
Construction Representatives	10.7%
Resident Office	8.9%

Responses were tabulated manually. The tabulated data was then entered into a TI professional computer (PC) using Lotus 1-2-3 spreadsheet software. Tables, bar graphs, and pie charts were used to summarize the findings. These findings are discussed in detail in Chapter 5.

Methodology for Comparing Findings with Other Studies.

The purpose of identifying other studies was to determine if the findings of this study were unique to the installation or District from which collected or universally applicable to the Corps of Engineers as a whole. Chapter 2 discussed the secondary sources of previously completed papers reviewed for the purpose of making that comparison. The comparison was made by identifying the key issues of this study and comparing the findings pertaining to those issues with the findings of the other studies. General trends were thereby established where possible for the three other segments of the study.

This analysis, by its nature, was more descriptive/qualitative than quantitative. From this analysis, it could be determined which findings appeared to be unique and which appeared to be part of the overall nature of military construction. These comparisons are discussed in detail in Chapter 7.

Summary.

This study consisted of three distinct phases, each of which required a different methodology. The first part, Causes and Costs of Modifications, required examination of project source documents to obtain data on individual items of change, reasons for each change, and the cost of each change. Additional data was obtained from management reports on indirect overhead costs. The second part, Evaluation of the Design Review System, involved collecting by questionnaire and analyzing opinions on specific issues of those individuals involved with the review system. Lastly, a descriptive method was used to compare the findings of this study to those of previous studies. The use of all of these methods provided a detailed inquiry into the overall modification picture as it applies to military construction.

CHAPTER 4

CAUSES AND COSTS OF CONTRACT MODIFICATIONS

General:

This chapter identifies the causes and costs of modifications to the 25 projects studied. It addresses the following research objectives:

1. identify the causes of modifications to military construction projects.
2. determine direct modification costs for the projects studied.
3. determine the indirect costs associated with modification processing.
4. identify the level of cost growth for DMA, MCA, and AFH projects.

Modifications were classified as being caused by design deficiencies, unknown site conditions, user requests, "no-fault" design changes, value engineering proposals, or "other". The "other" category included no cost administrative changes to contract wording, time extensions due to bad weather, occupant interference with contractors, and additional items not covered under the first five classifications. Items of change within each modification were analyzed and classified individually. The cost per item of change was determined from Eng Form 3938 and written contractor proposals. This approach allowed a thorough analysis of causes due to change items as well as the cost of those changes.

The remainder of this chapter is organized in the following manner. The causes of modifications for projects studied are presented in the next section, along with a discussion of design disciplines contributing most to design deficiencies. Modification cost and project cost growth are discussed next. Subsequent sections correlate cost growth with preconstruction reviews, project type, project size, and responsible design agency. The final section is a chapter summary.

Modification Causes.

Appendix 2 contains tables showing the causes of modifications by cost and by item of change, per project. Figure 5 summarizes the data from the cost tables. The primary sources of mod cost was found to be design deficiencies (36.3%), user requested changes (22.3%), and unknown site conditions (21.8%).

Figure 6 summarizes the results of the analysis by items of change. Design deficiencies were found to make up 33.2% of all items of change, followed by unknown site conditions (27.4%) and user requested changes (21.7%). Recall from the previous chapter that the percentages shown in both figures for design deficiencies are conservative.

A comparison of mod causes by cost and change item is shown in Table 8. Design deficiencies, unknown site conditions, and user requested changes are the three main causes of mods in both categories; together they make up 80% of mod costs and 83% of all items of change. The significance of this is that these mod causes are those which should be most influenced by thorough preconstruction reviews.

Figure 5
Sources of Modifications by Cost
Less High Cost Mods and Project 15

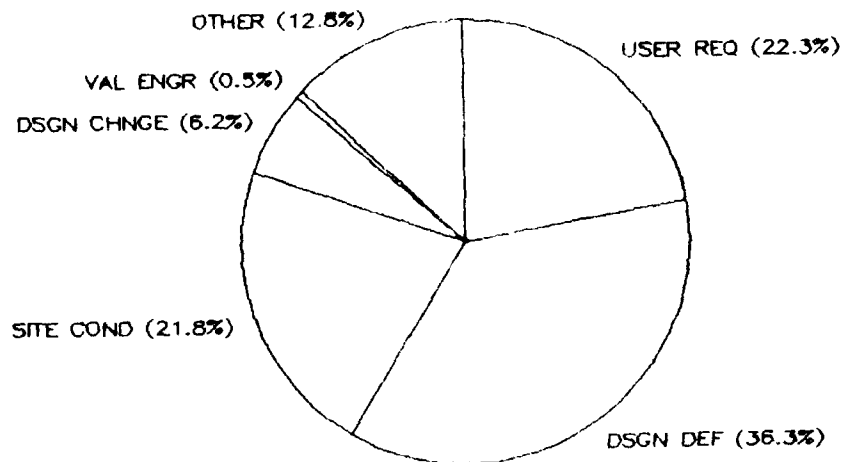


Figure 6
Sources of Modifications
By Items of Change

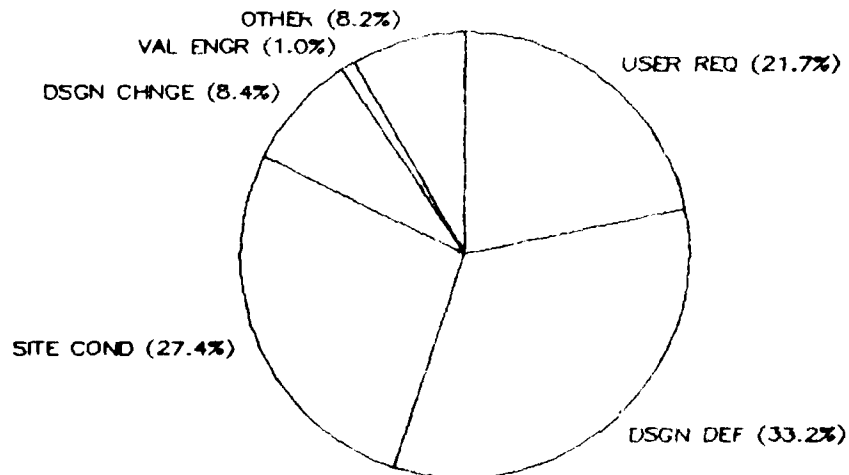


Table 8
Comparison of Modification Sources
Cost versus Items of Change

Cause of Modification	Percent by Item of Change	Percent of Total Mod Cost
Design Deficiency	33.2%	36.3%
User Requested Changes	21.7%	22.3%
Unknown Site Conditions	27.4%	21.8%
Design Changes	8.4%	6.2%
Value Engineering	1.0%	0.5%
Other	8.2%	12.8%

Causes of Design Deficiencies:

From the analysis done to determine the design disciplines in which design deficiencies occur, architectural items were found to have made up the largest share of design deficiencies. These findings are tabulated at Appendix 3 and summarized in Table 9. This analysis was also done on the basis of both items of change and cost. The figures show architectural items accounting for 41.7% of design deficiency items of change and 57.5% of design deficiency costs. Typical architectural modification items included location of non-load bearing walls, errors in door and window schedules, changes to finishes, improperly specified hardware, casements, cabinets, and improperly sized door frames. Deficiencies in mechanical design comprise the next largest portion, accounting for 23.6% of cost and 25.4% of change items. Typical mechanical problems included conflicts with ductwork routing and structural elements, HVAC design, and improperly designed/routed interior plumbing systems. Electrical deficiencies

make up 12.5% of change items but only 5.9% of cost. Structural, civil, and administrative changes together account for the remaining 20.4% of change items and 13.0% of cost. It is concluded from this that had reviews placed greater emphasis on the architectural and mechanical aspects of design significant cost growth savings may have been realized.

Table 9
Disciplines in Which Design Deficiencies Occur

Design Discipline	Percentage by Cost	Percentage by Items of Change
Architectural	57.5%	41.7%
Mechanical	23.6%	25.4%
Electrical	5.9%	12.5%
Structural	5.9%	10.4%
Civil	7.1%	5.0%
Admin Changes	-	5.0%

Modification Costs.

Costs were measured in three ways. The first was direct cost. This is the amount the government pays to the contractor as compensation for work performed. It includes labor, materials, profit, and impact items. The second measurement was indirect costs incurred by the district, which include overhead for modification design, processing, negotiations, and other administrative tasks consume employee time accounted for under various cost codes. The third method evaluated the effort expended in mod processing because time spent on modifications is time not available for construction.

inspection, design, reviews, and other tasks. Thus, modification processing has a direct effect on district productivity.

Using these three cost measurement techniques provided a comprehensive assessment of overall modification cost. There are, however, two additional, intangible costs. These are the loss of customer satisfaction and damage to the Corps' professional reputation. These nonquantifiable costs will be discussed further in Chapter 6.

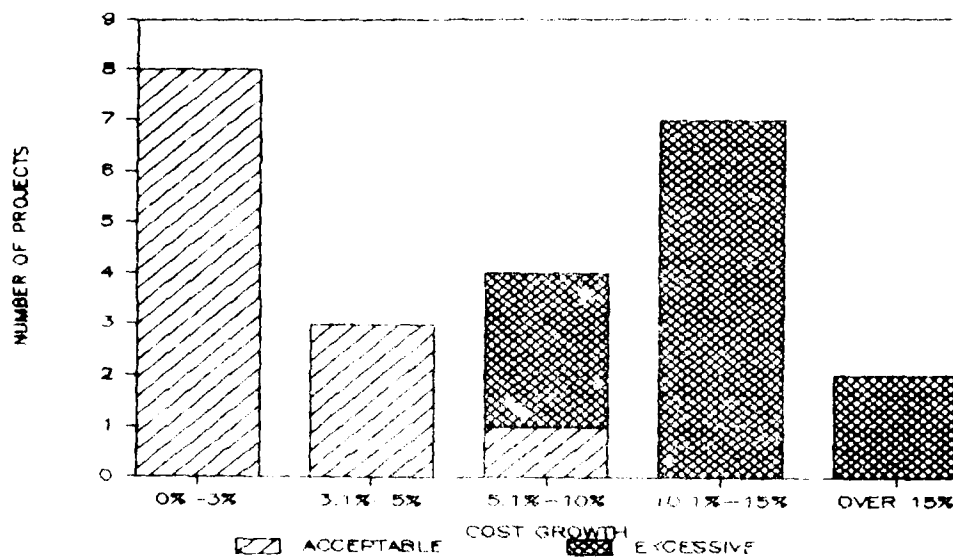
The 25 projects studied represent total contract amounts of almost 26 million dollars. Total direct modification costs amounted to almost 2.4 million dollars, for an overall cost growth of 9.4%.

A frequency distribution of the number of individual projects falling within various cost growth brackets is shown in Figure 7. Recall that in Chapter 1, "acceptable" levels of cost growth were assumed depending on project scope. These levels were 3% for new, "from the ground up" projects, 5% for new work in existing buildings or non-complex renovation work, and 10% for renovation work involving complex mechanical or electrical work in older buildings. Figure 7 shows that 12 out of 24 projects (50%) exceeded these acceptable cost growth levels. This represents more than an expense to the taxpayer. Excessive cost growth reduces customer satisfaction, degrades the Corps' professional reputation, and decreases district productivity by diverting manhours from design, reviews, inspections, and other activities.

Controlling direct cost can result in substantial savings. Table 10 illustrates how much may have been saved if cost growth on

those projects with excessive costs had been held to acceptable levels. In several cases, even though the savings represents a reduction of only two or three percentage points, the dollar cost savings is significant. The total savings amounts to approximately \$380,000. If the high cost items previously deleted from calculation were included, the total savings rises to over \$1,250,000.

Figure 7
Cost Growth Frequency Distribution
Less High-Cost Mods and Project 15



District indirect cost for engineering, design, and overhead amounted to \$129,000. \$113,800 of this was spent on modification design. If an hourly rate of \$20 is assumed, this amounts to 5690 manhours (2.9 man-years) of a GS-11 engineer's time. This represents a significant drain on overall design productivity. This figure, however, does not represent total indirect costs. All time spent by

personnel in the district's Construction Division were accounted to a general "construction" account and was impossible to trace to individual projects. Consequently, actual indirect costs are much higher. A summary of engineering, design, and overhead costs is at Appendix 5.

Table 10
Potential Savings From Control of Direct Cost Growth

PROJECT NUMBER	ADJ CONTR AMOUNT	ACTUAL COST GROWTH	ACCEPTABLE COST GROWTH	POTENTIAL SAVINGS
1	\$ 796,000	\$140,390 (17.6%)	\$ 79,600 (10%)	\$ 60,790
2	\$ 83,000	\$ 10,467 (12.6%)	\$ 4,150 (5%)	\$ 6,317
3	\$4,637,000	\$235,468 (5.1%)	\$139,110 (3%)	\$ 96,358
6	\$ 224,576	\$ 24,115 (10.7%)	\$ 11,229 (5%)	\$ 12,886
10	\$ 79,191	\$ 5,814 (7.3%)	\$ 3,960 (5%)	\$ 1,854
11	\$ 488,970	\$ 55,632 (11.4%)	\$ 24,449 (5%)	\$ 31,184
13	\$ 209,603	\$ 27,539 (13.1%)	\$ 10,480 (5%)	\$ 17,058
14	\$ 860,518	\$161,420 (18.8%)	\$ 86,052 (10%)	\$ 75,368
16	\$ 207,500	\$ 25,145 (12.1%)	\$ 10,375 (5%)	\$ 14,770
17	\$ 411,373	\$ 52,320 (11.8%)	\$ 20,569 (5%)	\$ 31,751
20	\$ 267,000	\$ 19,367 (7.3%)	\$ 13,350 (5%)	\$ 6,017
23	\$ 505,742	\$ 53,098 (10.5%)	\$ 25,287 (5%)	\$ 27,811
TOTAL:				\$382,164
IF HIGH DOLLAR MODS AND PROJECT 15 ADDED:				
5	\$4,666,590	\$411,844 (8.8%)	\$233,330 (5%)	\$178,515
15	\$ 536,300	\$477,408 (89.0%)	\$ 53,630 (10%)	\$423,778
22	\$1,247,433	\$331,873 (26.6%)	\$ 62,372 (5%)	\$269,501
TOTAL				\$871,794
GRAND TOTAL				\$1,253,958

An attempt was made to correlate indirect costs with other variables such as project size, design agency, and project type. No correlation with any of these variables was found. Engineering,

design, and overhead costs per item of change averaged \$165; costs per modification averaged \$483. Figure 8 is a frequency distribution showing the number of items of change falling into each of six cost brackets. The graph shows how many projects had an average indirect cost per item of change falling between the brackets shown. The mode was for projects to have their average cost per item of change for E&D and overhead to be less than \$100. There is, however, no consistent pattern for items outside this range. Figure 9 is a similar distribution but presents the cost per modification. Again, the vertical axis indicates how many projects had an average cost per mod falling within the designated brackets. As can be seen, no clear pattern is discernible. The conclusion drawn from this is that engineering design and overhead costs appear to be a function of mod design complexity, which varies with each modification. Hence, generalizations concerning relationships between these costs and other factors cannot be made.

Modification cost may be measured in terms other than dollars. Mods consume numerous manhours of personnel (other than design) involved in mod processing. An estimate of how much time was involved was made by asking those involved in mod processing to identify what percentage of a typical week was spent on various activities, to include modification processing. Within the supporting District, the three offices showing the most effort expended on mods were the resident office (21% to 35%); design branch (6% to 13%); and quality assurance branch (12% to 20%). The time consumed by mod processing in the resident office is often cited as the reasons other essential work,

such as constructibility reviews, is not done in the detailed manner that it should be. While the ranges for design branch and quality assurance are probably not excessive considering overall work load, they do represent a significant amount of time that could more productively be spent on design or design review.

Figure 8
Frequency Distribution of Engineering, Design, and Overhead
Cost per Item of Change

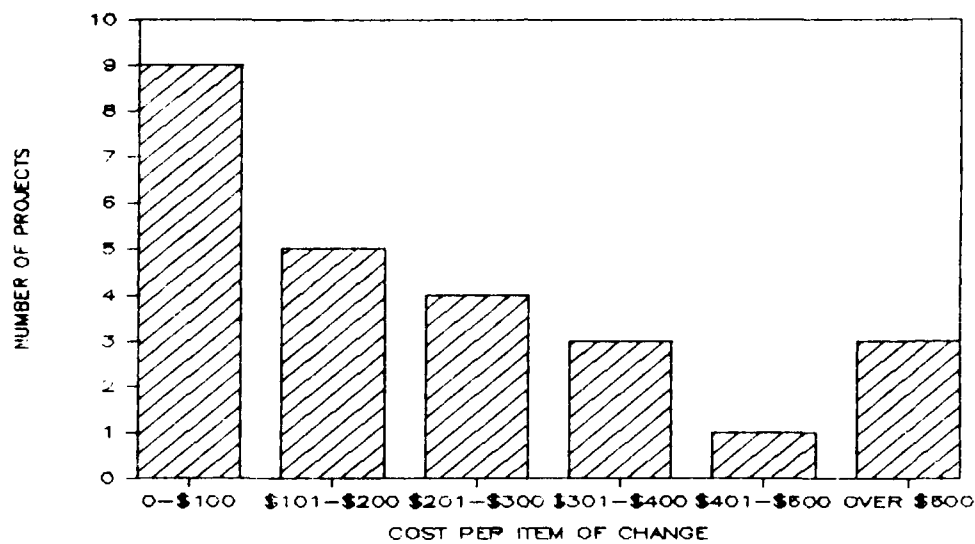
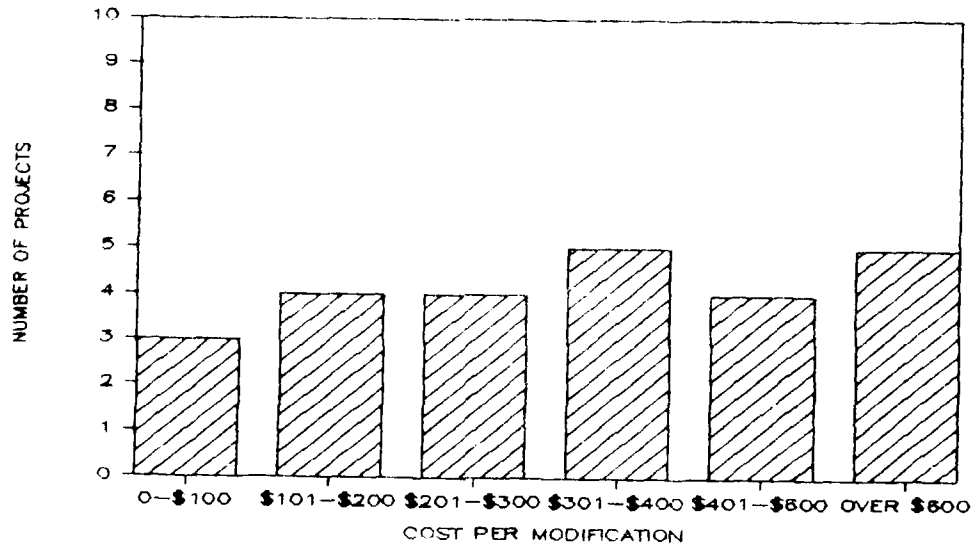


Figure 9
Frequency, Distribution of Engineering, Design, and Overhead
Cost per Modification



Cost Correlation by Design Review:

This section analyzes the projects on the basis of preconstruction reviews. Three types of reviews were considered: constructability, technical, and using service. Personnel familiar with each project were contacted in the supported installation Directorate of Engineering and Housing (DEH), the local Corps of Engineers resident office, and the supporting District headquarters to identify which projects received which reviews. There were often differing perspectives on what reviews took place for a given project between these agencies. For the purposes of this study, if anyone in any of the contacted agencies attested to a review having taken place

for a particular project, that project was classified as having been given that review. Reviews were considered on a "yes or no" basis only. No attempt was made, at this point in the study, to establish the quality of the review conducted.

Table 33 of Appendix 4 indicates 21 projects were reviewed for constructability, technical sufficiency, and using service requirements. Four projects (including Project 15) are shown as having one or more of these reviews missing. Projects which received all three reviews show mod costs amounting to 4.7% of their summed contract bid amounts. Projects not receiving all reviews show a cumulative cost growth of 35.6%. When adjusted by deleting Project 15, this percentage drops to 15.4%. Thus, it may be concluded that projects which are not carefully reviewed for technical sufficiency, constructability, and user serviceability tend to result in higher overall cost growth.

The histograms at Figures 10 and 11 provide a frequency distribution of cost growth for projects receiving and not receiving all three reviews. Figure 10 shows that the four projects not receiving all three reviews exceeded acceptable cost growth levels. Figure 11 presents a frequency distribution for projects having received all three reviews. Although the overall cost growth for reviewed projects was lower than the cost growth for non-reviewed projects, nine of the 21 reviewed projects still had unacceptably high levels of cost growth. This may indicate that preconstruction reviews were not conducted with the same degree of thoroughness for all projects, and did not consistently result in precluding problems before construction began.

Figure 10
Cost Growth of Projects not Receiving all 3 Reviews

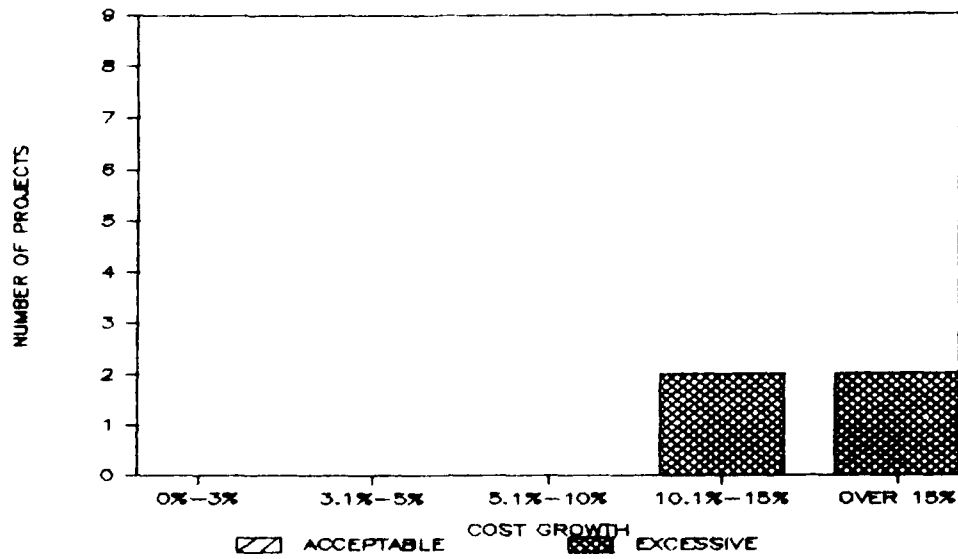


Figure 11
Cost Growth of Projects Receiving all 3 Reviews

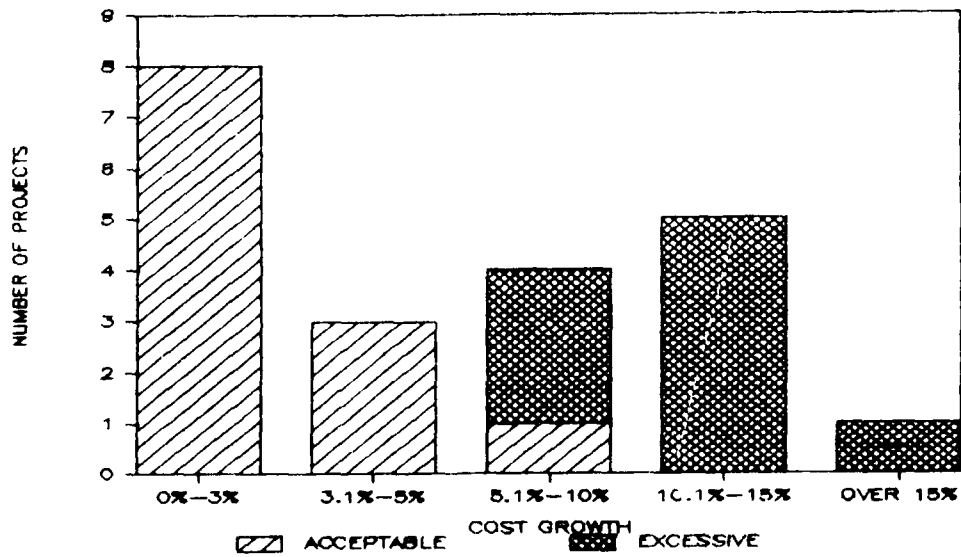


Table 11 presents a comparison of the causes of modifications as a function of review. Projects receiving all three reviews show a significantly lower percentage of cost growth (33.7%) due to design deficiencies than do non-reviewed projects (50.2%). There is, however, only a modest decrease in problems with unknown site conditions (28.7% to 20.5%). Consequently, it may be concluded that reviews, as currently conducted, do not adequately reduce the effects of cost growth due to problems with site conditions and user requested changes. The problem with site conditions was probably due to a lack of site visits conducted as part of the design and review process, while poor project scope definition was a major contributor to user requested modifications. This appears to be most significant with loosely designed "year-end-crunch" projects (such as Project 15).

Table 11
Causes of Modifications
Correlated by Review

Modification Causes	Percentage of Mod Cost	
	Projects Receiving all Three Reviews	Projects Not Receiving all Three Reviews
Design Deficiency	33.7%	50.2%
User Requests	15.8%	4.5%
Site Conditions	20.5%	28.7%
Design Changes	6.5%	4.5%
Value Engineering	0.6%	0.2%
Other	13.0%	12.0%

NOTE: The quality of the review conducted was not considered at this point in the study.

Cost Correlation by Project Type:

The 25 projects studied contained three different types of projects. These were Army Family Housing (AFH); Military Construction, Army (MCA); and Operation and Maintenance, Army (OMA). Five of the projects studied were AFH, five were MCA, and 15 were OMA. One of the five MCA projects is minor MCA which, for the purposes of this study, will be treated as MCA. Table 34 of Appendix 4 contains data for projects categorized under each project type.

Cost growth averaged 9.4% for AFH projects; 4.2% for MCA projects; and 6.7% for OMA projects. Figures 12, 13, and 14 illustrate how many of each type of project which experienced unacceptable levels of cost growth. Figure 12 shows data for AFH projects; note that four out of five (80%) of the AFH projects had excessive levels of cost growth. OMA data, shown at Figure 13, is similar; eight out of 15 projects (53%) had unacceptable cost growth levels. Conversely, the data for MCA projects shows only one out of five (20%) experiencing cost growth problems. In general, MCA projects tend to experience lower levels of cost growth than do AFH and OMA projects.

Two the five AFH projects (60%) did not receive all three preconstruction reviews. Of the three which did get fully reviewed, two had unacceptably high cost growth. Two of the 15 OMA projects did not receive all three reviews, and each of these two had cost growth of over 15%. Of the 13 OMA projects which received all three reviews, six still registered unacceptable levels of cost growth. All MCA projects received all three reviews. Only one MCA project exceeded its acceptable cost growth level, but only by two percentage points

(Project 3). This indicates that MCA projects were more carefully reviewed and have correspondingly lower cost growths than do OMA and AFH projects. The fact that six of the OMA projects and two of the AFH projects which received all three preconstruction reviews still had unacceptably high cost growth indicates that reviews for these types of projects tend to be less thorough than those given MCA projects. Furthermore, OMA and AFH projects are more susceptible to end-of-the-year funding pressures. Consequently, they are more likely to be released for bid with only cursory review.

Figure 12
Cost Growth by Project Type
AFH Projects

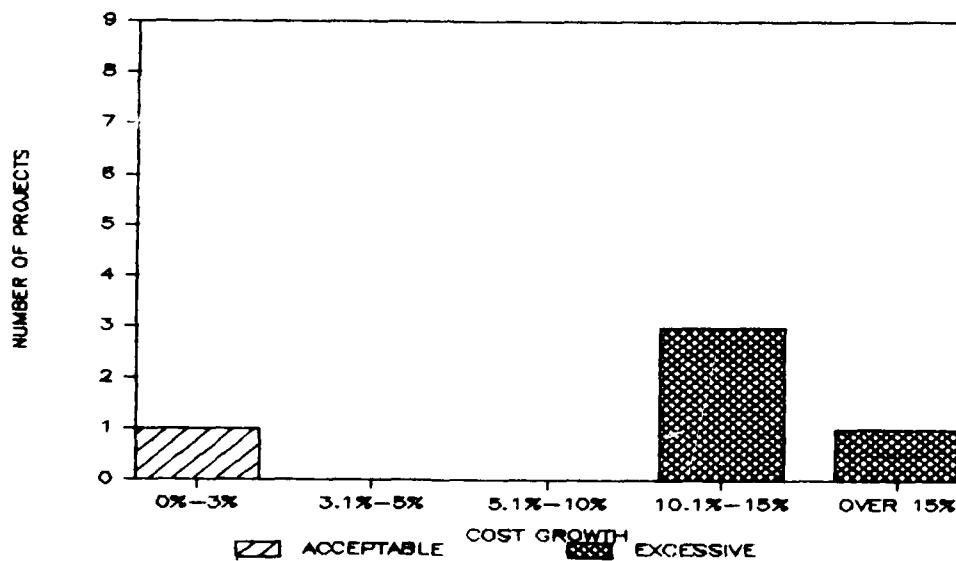


Figure 13
Cost Growth by Project Type
QMA Projects

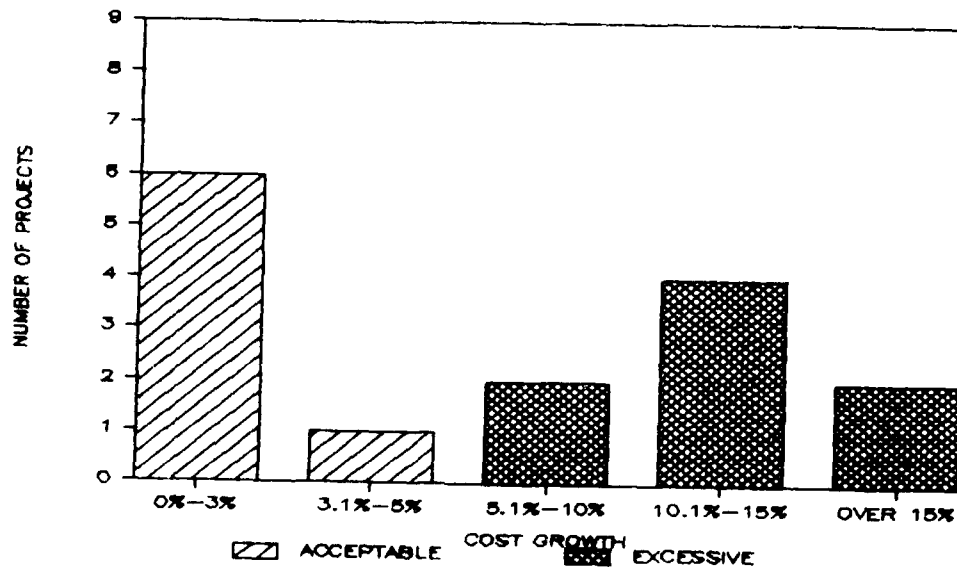
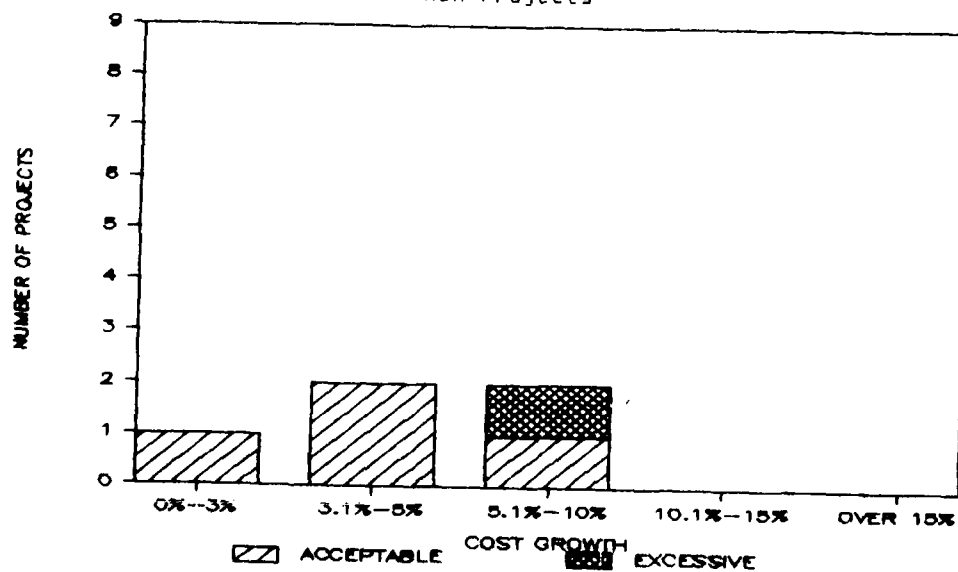


Figure 14
Cost Growth by Project Type
MCA Projects



The causes of modifications for each project type is shown in Table 12. Design deficiencies, site conditions, and user requested changes were the main causes of mods for each project type, although AFH projects appeared to be more subject to criteria design changes than did DMA or MCA projects. Note that although MCA projects tended to have lower modification costs than DMA and AFH projects, and although they appeared to be more carefully reviewed, they still had large numbers of modifications due to design deficiency that were obviously not being caught by the review process.

Table 12
Causes of Modifications
Correlated by Project Type

Modification Causes	Percentage of Mod Cost		
	DMA	AFH	MCA
Design Deficiency	40.2%	16.9%	40.3%
User Requests	18.6%	18.2%	25.7%
Site Conditions	24.5%	20.1%	21.3%
Design Changes	0.3%	16.9%	4.5%
Value Engineering	0.0%	0.0%	0.8%
Other	16.3%	21.9%	7.5%

Cost Correlation by Project Size:

An analysis by project size was conducted to determine the correlation, if any, between cost growth and adjusted contract amount. The 25 projects studied ranged from \$71,432 to \$4,666,590. Projects were divided into three categories based on contract amount. Thirteen projects had an adjusted contract amount of less than \$500,000; six

between \$500,000 and \$1,000,000; and six over \$1,000,000. Table 35 of Appendix 4 presents the data for projects under each of these classifications.

Projects whose adjusted contract amount was less than \$500,000 had an overall cost growth of 7.7%; those between \$500,000 and \$1,000,000 were at 12.8%; and those over \$1,000,000 at 3.5%. Figures 15, 16, and 17 are histograms showing the cost growth of projects within each cost category. Figure 15 shows that eight of the 13 (61.5%) least expensive projects had cost growth exceeding acceptable limits. Figure 16 shows four of the six (66.7%) projects contracted for between \$500,000 and \$1,000,000 have excessive cost growth. In contrast, only one out of six (16.7%) of projects over \$1,000,000 exceed acceptable levels, and that one only exceeds the limit by two percentage points. This may indicate that more expensive projects tend to receive greater attention in controlling cost growth than do less expensive projects.

This conclusion is further supported by the number of projects within each category receiving all three preconstruction reviews. All projects contracted for over \$1,000,000 received all three reviews. However, two projects of less than \$500,000 and two between \$500,000 and \$1,000,000 did not receive all reviews. Additionally, the lower costing projects tended to be OMA and AFH projects. These budgets were controlled by the installation and therefore more likely to be caught in the crunch for end-of-year funds and therefore possibly reviewed in a less than thorough manner. A comparison between project type and adjusted contract amount is shown in Table 13.

Figure 15
Cost Growth by Project Size
Projects Less Than \$500,000

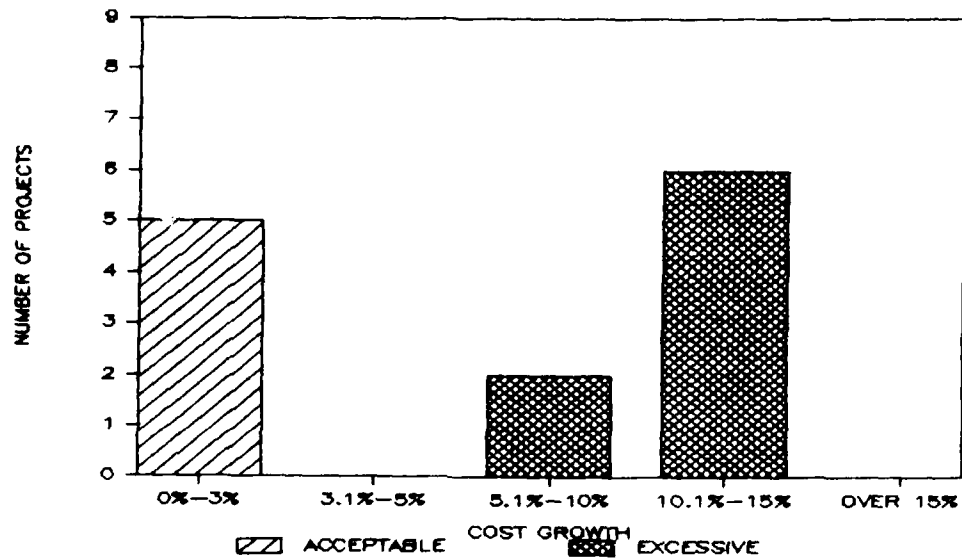


Figure 16
Cost Growth by Project Size
Projects Between \$500,000 and \$1,000,000

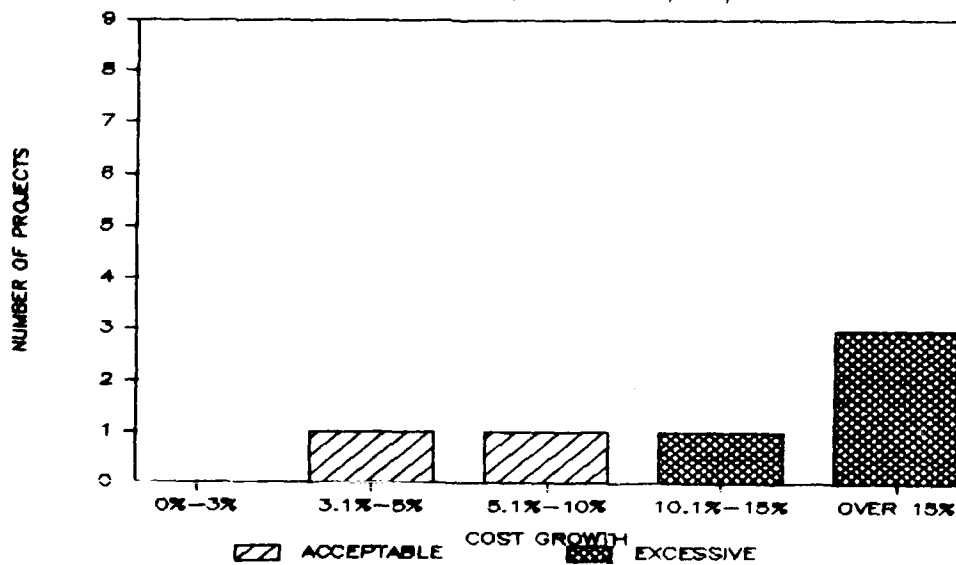


Figure 17
Cost Growth by Project Size
Projects Over \$1,000,000

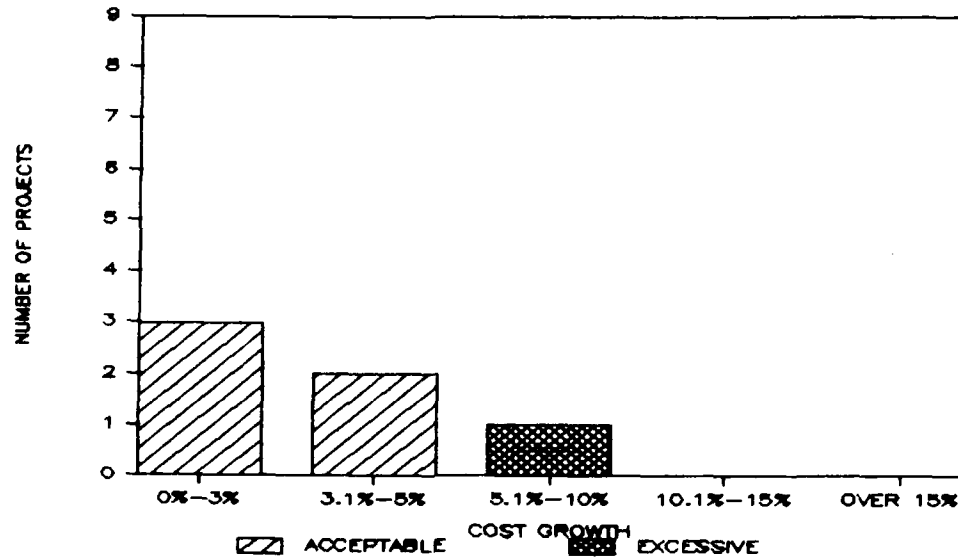


Table 13
Correlation Between Project Type
and Adjusted Contract Amount

Adjusted Contract Amount (\$000)	Overall Cost Growth	Number Projects	Number Projects	Number Projects
		OMA	AFH	MCA
UNDER \$500	7.7%	11	2	0
\$500 - \$1,000	12.8%	3	2	1
OVER \$1,000	3.5%	1	1	4

The data in this table indicates project size may be more of a determinate in cost growth than project type. This may be due to the fact that larger projects tended to be assigned the more experienced

project managers, are more thoroughly reviewed, and in general receive more intensive management than do smaller projects.

Table 14 illustrates the causes of modifications for each size category of project. The table indicates that design deficiencies, user requests, and site conditions are the main causes of mods for each size grouping of projects. Of significance is the "other" classification for the two lesser cost categories. Two major components of "other" costs in these projects were site accessibility and occupant interference. Many of the AFH and DMA projects were constructed under conditions of joint occupancy. In other words, the contractor and user both occupied the facility during construction. This in turn often led to conflicts resulting in the contractor claiming lost time and impact costs for schedule interruptions.

Table 14
Causes of Modifications
Correlated by Project Size

Modification Causes	Percentage of Mod Cost		
	Less Than \$500,000	\$500,000 - \$1,000,000	Over \$1,000,000
Design Deficiency	53.4%	21.5%	40.5%
User Requests	19.3%	20.3%	24.6%
Site Conditions	8.9%	29.0%	21.1%
Design Changes	1.5%	12.2%	4.6%
Value Engineering	0.0%	0.1%	0.9%
Other	16.9%	17.0%	8.3%

Although the smaller projects had higher percentages of cost growth, their total dollar amount of mod costs is relatively small

(Table 15). However, these projects were often built at a much higher level of visibility to the customer than are larger projects. High cost growth rates have an impact on customer satisfaction not reflected in the dollar cost, particularly those projects funded by the installation.

Table 15
Dollar Amount of Cost Growth
By Project Size

Adjusted Contract Amount (\$000)	Overall Cost Growth	Number of Proj	Cost of Modifications
UNDER \$500	7.7%	13	\$227,038
\$500 - \$1,000	12.8%	5	\$467,609
OVER \$1,000	3.5%	6	\$647,486

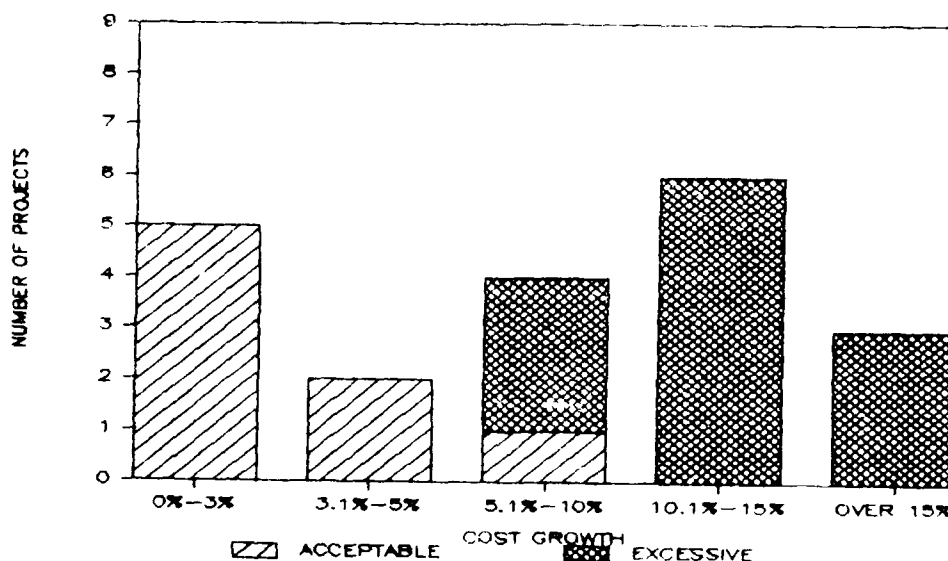
Cost Correlation by Designer:

Military construction projects are designed by either in-house government employed engineers and architects or by privately owned firms contracted for that purpose. In-house designs may be by either DEH personnel at the installation or by the supporting district. 20 of the 25 projects studied were designed by contracted architectural/engineer (A/E) firms. Of the five in-house designed projects, three were done by the installation and two by the district. Table 36, Appendix 4, shows the projects designed by each agency.

Projects designed by in-house personnel had an overall cost growth of 2.8%. This is less than half of the 5.9% overall cost growth experienced by A/E designed projects. Figures 18 and 19 illustrate the

number of projects designed by each source of design that experienced unacceptable levels of cost growth. Figure 19 is the data for A/E designed projects. Note that 11 of 19 (58%) of A/E projects had excessive levels of cost growth. In contrast, only one of five (20%) in-house designed projects had unacceptable levels of cost growth. This indicates that for the projects on the installation under study, in-house designers tended to do a better job of project design and/or review than did contracted A/E firms.

Figure 18
Cost Growth by Design Agency - Contracted A/E Firms



The causes of mods within each design grouping is shown in Table 16. Of significance is that 23.5% of the mod costs to projects designed by A/E firms was due to unknown site conditions compared to only 6.7% for in-house designs. This may have been a result of

in-house designers having more ready access to construction sites during the design phase and being more familiar with project location than did contracted A/E firms. It could also have been a function of the A/E failing to visit the site, either due to lack of funding or for other reasons.

Figure 19
Cost Growth by Design Agency - In-House Government Designers

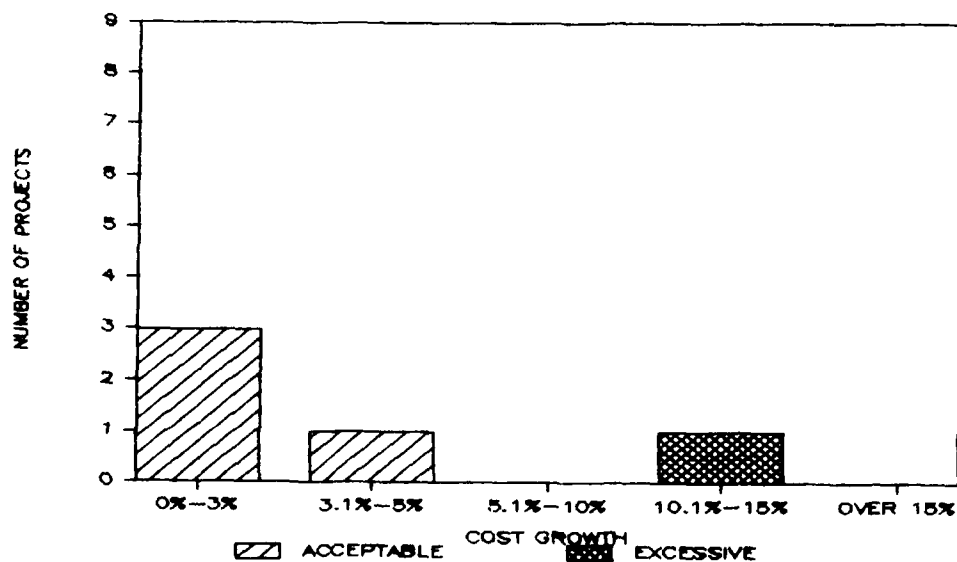


Table 16
Modification Causes
Correlated by Design Agency

Modification Causes	Percentage of Mod Cost	
	Designed In-House	Designed by Contract A/E
Design Deficiency	41.3%	35.8%
User Requests	27.7%	21.7%
Site Conditions	6.7%	23.5%
Design Changes	5.6%	6.3%
Value Engineering	0.0%	0.6%
Other	18.7%	12.2%

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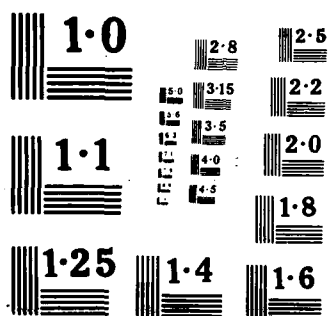
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Summary:

This chapter discussed modification causes, cost growth, direct and indirect costs, and the impact of mod processing on productivity. It presented a correlation of cost and causes with preconstruction reviews, project type, project size, and design agency. An examination was made on the basis of items of change to each project contract as well as the cost of each item of change. Design disciplines contributing most to design deficiencies were identified. Design deficiencies, unknown site conditions, and user requested changes were identified as the major source of contract modifications.

The correlation between cost growth and review leads to the conclusion that modifications, by themselves, were not the real problem but rather a symptom of a greater problem. Obviously, perfect designs would not result in changes. Equally obvious is the fact that there is no such thing as a perfect design. Therefore, a systematic and thorough design review process is essential to keeping contract changes (and corresponding cost growth) under control. The fact that 50% of the projects studied exceeded acceptable levels of cost growth indicated a major problem with the review system in use. An evaluation of that system is the subject of the next chapter.

CHAPTER 5

THE PRECONSTRUCTION DESIGN REVIEW SYSTEM

General:

This part of the study was designed to evaluate the preconstruction review system used by the Corps of Engineer District which built the projects examined. Of the 21 projects that had been given using service, constructibility, and technical design reviews, nine (43%) still had unacceptably high levels of cost growth. Furthermore, it was found that 80% of all cost growth was due to design deficiencies, user requested changes, and unknown site conditions. Of all the reasons identified for cost growth, these three should be the most easily influenced by thorough preconstruction reviews.

The supporting District had design responsibility for 13 (52%) of the 25 projects. The remainder were either designed in-house by the installation DEH or contracted to A/E's by the DEH. In these cases, the district could only review projects after the completed design had been forwarded for construction. But of the 13 projects the district (or its contracted A/E's) did design, seven (54%) had excessive cost growth. This implied the District's review system was not fully effective in correcting problems prior to contract award. It was suggested in the last chapter that excessive mods and cost growth are not of themselves a problem, but rather a symptom of a larger problem. The objective here is to determine where within the review process that problem might be.

The primary source of data was a questionnaire collected from 56 district employees. Respondents included all construction representatives and office engineers located at the resident office, engineers working in Quality Assurance Branch of the Construction Division, engineers working in Design Branch and Foundations and Materials Branch of Engineering Division, and project managers. The findings which follow are a compilation of the subjective responses of these individuals to those questions. A copy of the questionnaire is at Appendix 6.

The study covered only those constructibility and technical reviews conducted by the district. Reviews by Division of District in-house designs, reviews contracted out to private A/E firms, and installation using service reviews were not addressed.

This was not intended to minimize the importance of using service reviews. Functional reviews by the installation are essential to reducing user requested modifications. In general, it appeared that poor project scope definition was a major contributor to user requested mods. Projects were designed and let for bid without a firm scope definition being communicated to the designer or user. Consequently, the designer may not have been aware of what the customer wanted and the customer not aware of what was designed until construction actually began. This problem was aggravated by personnel rotations at the installation which often resulted in the ultimate user being unfamiliar with design decisions made by his predecessor. The DEH must play the major role in addressing this issue. Improved coordination between the District and DEH to include functional reviews conducted early in the

design cycle and including designers, project managers, DEH, and the using agency would be a major step in resolving this problem. This area requires further study as to specific causes of user requested mods and solutions.

The chapter is organized to individually discuss each of the three main variables the questionnaire was designed to address. These variables were:

1. The training, experience, and motivation of review personnel.
2. The time available with which to do reviews.
3. The organizational and procedural framework within which reviews are conducted.

The questionnaire was designed to obtain respondent perceptions and experiences in these areas. Each is discussed in the sections which follow.

Personnel Qualifications:

Questions in the questionnaire concerning personnel qualifications were designed to evaluate three areas:

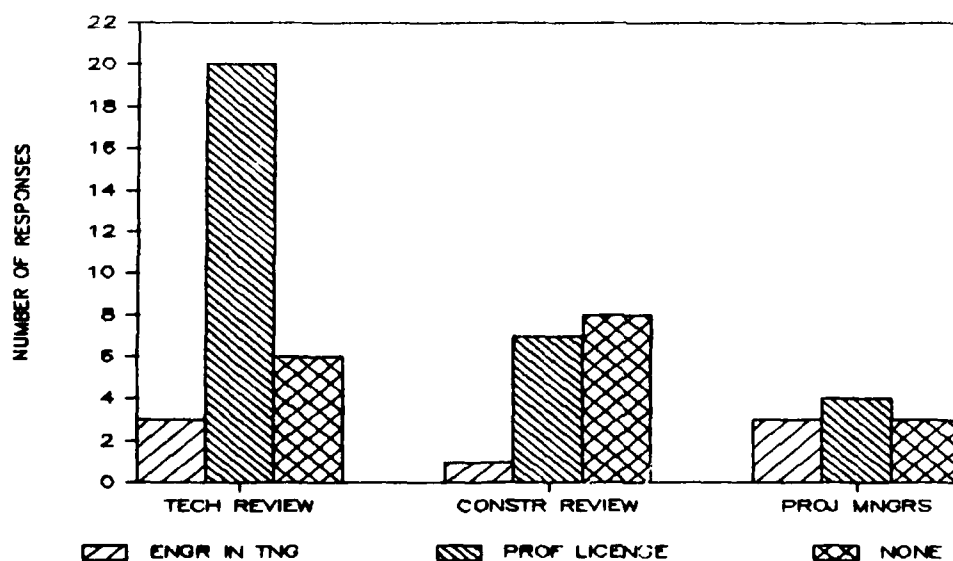
1. Education/training/professional qualifications of personnel conducting reviews. This includes academic degrees held, professional licensing, and training in how to conduct technical/constructibility reviews.
2. Experience in engineering design and construction. This includes experience both inside and outside of government service.
3. Attitude and motivation toward the conduct of reviews.

The percentage of reviewers holding professional degrees was fairly high. 87.5% of all respondents held at least bachelor degrees

in a professional discipline. Those not holding degrees generally were construction representatives and engineer technicians working in Construction Division whose responsibilities depend more on experience than academic background.

The proportion of professionally registered personnel was also high. 38 of the 56 (68%) respondents held professional licenses or training certificates. A breakdown of professional registration by review category is at Figure 20. The largest number of those not holding professional licenses were construction representatives. The figure includes registration as a professional engineer, architect, landscape architect, or other professional field.

Figure 20
Professional Registration (Questions 41, 42, and 43)



Respondents were asked to identify training they had received, if any, in review techniques. The majority (55.0%) stated they learned how to do reviews through "experience". 33.9% indicated training in some kind of formal course. Responses of where this training was received included an engineering graphics course, training in the Navy, courses in value engineering, the Corps of Engineers Military Design Review Course (most common response), review seminars and in-house training, and courses taught at the United States Army Engineer School at Fort Belvoir. 11.2% stated they have learned how to do reviews through on-the-job training (OJT). Although a couple of respondents clearly identified a formal OJT program, it is not entirely clear if the others intended OJT to mean a formal, structured program or if this was another way of stating they learned through experience. Consequently, the percentages for "experience" and "on-the-job training" are probably not as clear-cut as shown and should be interpreted accordingly. In any event, it is clear that a standard base of training did not exist. Reviewers approached each review from the framework of past experience. This does not lend itself to providing a consistent review product due to the varied backgrounds of the individuals concerned.

Respondents were asked to identify their experience in the areas of design, construction, construction management, and total time in the Corps (either at District or DEH). Table 17 summarizes the responses given. Only five of the 56 respondents (three construction representatives and two quality assurance personnel) had less than two years with the Corps. The majority had over five years, with 60% of

the project managers, 59% of the design engineers, and 60% of the resident office personnel having over ten years total Corps experience.

Of the 29 respondents involved with technical reviews, only 3 (10%) had less than two years experience in design. All 11 individuals claiming over 20 years design experience were individuals responsible for technical reviews. Their experience with construction, however, was limited. 69% had less than two years; 86% less than five years construction experience.

Table 17
Professional Experience (Questions 35, 37, 38, and 39)

Number of Responses (Percentage)

Experience	0-5 yrs	5-10 yrs	10-20 yrs	Over 20 yrs
In Corps	10 (18%)	16 (28%)	20 (36%)	10 (18%)
As Designer	27 (48%)	10 (18%)	8 (14%)	11 (20%)
In Construction	37 (66%)	3 (5%)	6 (11%)	10 (18%)
As Constr Mngr	36 (69%)	4 (8%)	8 (15%)	4 (8%)

NOTE- Only 52 respondents answered question on Construction Management experience.

Constructibility reviews required less experience in formal design and more in actual construction. 81% of the respondents responsible for constructibility reviews claimed over ten years experience in construction. However, just as technical reviewers had relatively little construction experience, those responsible for constructibility reviews had limited design experience. Only five (29%) indicated having over five years experience in design.

60% of project managers had between ten and 20 years in the Corps of Engineers, and 30% between two and five years. This time was spent between technical design and construction management type

positions. They had virtually no experience in construction; 90% reported having less than two years construction experience. Most had none.

Respondents were asked to subjectively evaluate how often they were able to conduct thorough reviews within their areas of expertise. The results are shown at Figure 21. 45 of the 51 (88%) answering this question felt their experience qualified them to do good reviews "always" or "most of the time". They were then asked to identify those disciplines in which they felt qualified to do reviews (based either on education, training, or experience), and in which disciplines they were actually required to conduct reviews. The results are shown in Figure 22. In only a couple of instances were individuals required to conduct reviews outside their areas of expertise. This indicates that, except in rare cases, the qualifications of reviewers matched the work load requirement within the various design disciplines.

Attitude toward reviews was evaluated based on opinions expressed concerning the need for reviews and the perceived value of reviews in reducing construction costs. Figures 23 and 24 summarize the answers to these questions. The overwhelming majority of respondents felt reviews were necessary either "always" or "most of the time". 95% replied that reviews are necessary regardless of project size. 89% responded that reviews are needed regardless of who the project is designed by. As seen in Figure 24, 77% of the respondents indicated that reviews will reduce cost growth either "always" or "most of the time". It can be concluded that the greater majority of those involved feel reviews are important and do save the government money.

Figure 21
Ability to Conduct Reviews (Question 22)

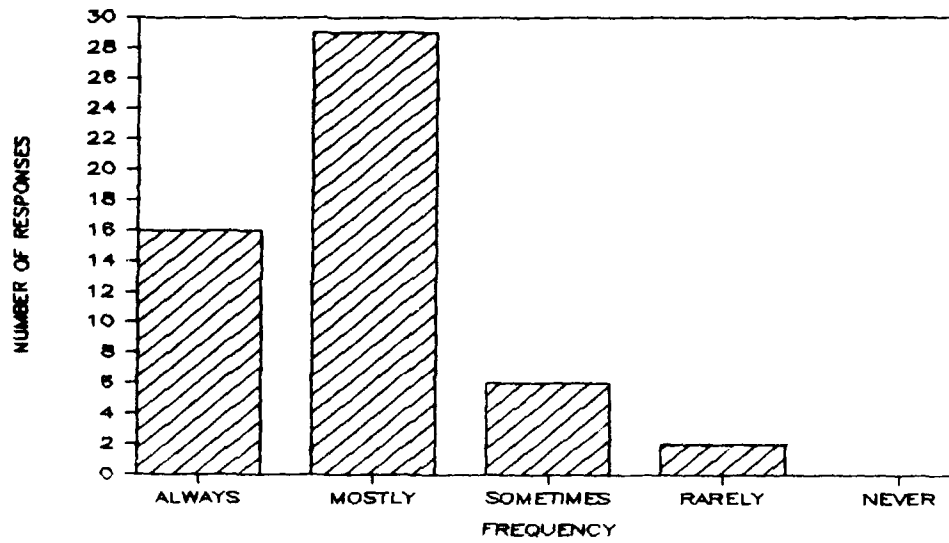


Figure 22
Review Qualifications vs Review Workload in
Each Design Discipline (Question 4 and 5)

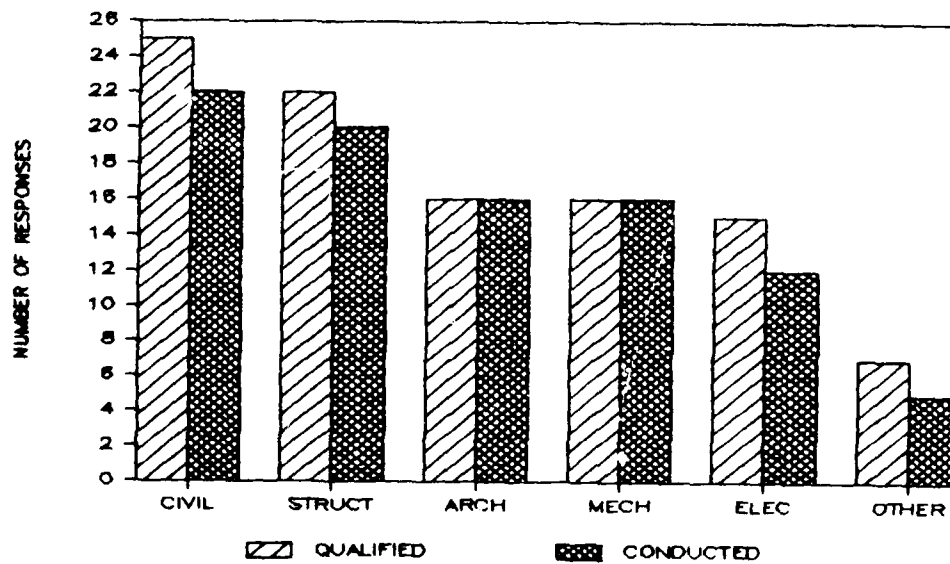


Figure 23
Opinions on How Often Reviews are Needed (Questions 16 and 17)
(Based on Size of Project and Design Agency)

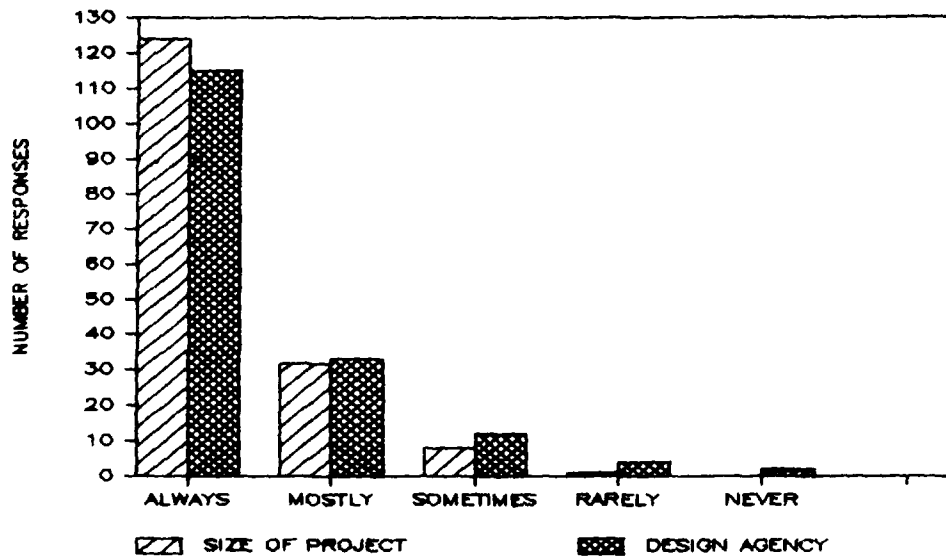
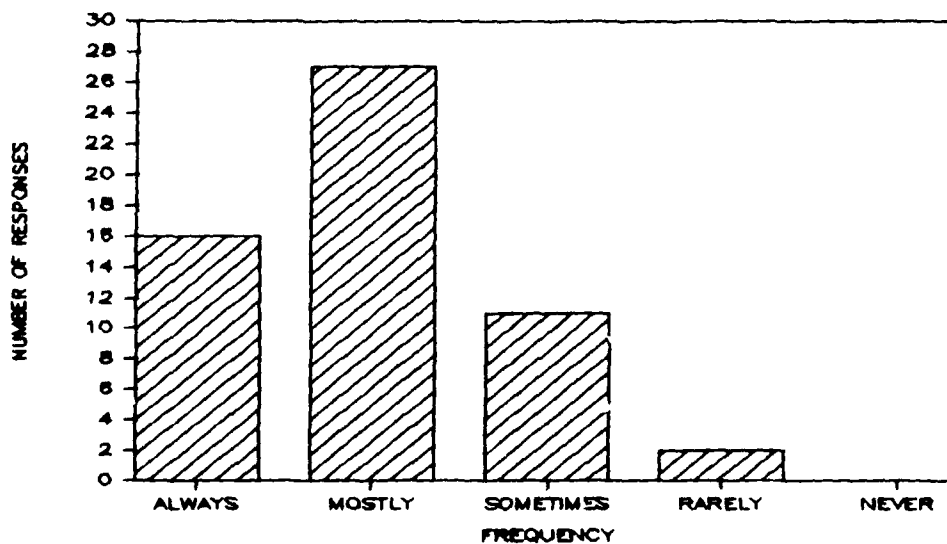


Figure 24
Opinions on How Often Reviews Save the Government
Money (Question 26)



In summary, the data collected indicate those doing technical reviews had the requisite education and experience in engineering design, while those doing constructibility reviews had extensive experience in construction. Project managers, whose role was the coordination and management of reviews and review comments, tended to have less overall experience than reviewers. They were found to be weak in the area of construction, due mostly to the fact that project managers tend to be drawn from the ranks of designers. However, the experience they did possess in the areas of construction management was sufficient to meet their review coordination responsibilities. Consequently it was concluded that, although there was little cross training between disciplines, reviewers in general had the required education and experience to carry out review tasks within their respective areas. The only weak areas noted were in cross training between design and construction personnel and in the lack of a standardized training base.

Question 34 asked for an unqualified evaluation of the quality of reviews conducted by the respondents. 40% replied that reviews were only "sometimes" as thorough as the project warranted. This is in significant contrast to the confidence and qualifications discussed above. Therefore, there must have been other factors other than personnel qualifications affecting review quality. These other factors will be discussed in the subsequent sections.

Time Available for Reviews:

The analysis of time was done by determining the time required

to do a review, the time needed to work reviews in with other job requirements, and the time actually provided. The questionnaire asked for review time as it related to small (less than \$500,000), medium (between \$500,000 and \$1,000,000) and large (greater than \$1,000,000) projects. Additionally, the timing of submittal for 15 projects designed by DEH and forwarded to the district for construction was examined to determine if the installation was at fault in providing insufficient time to allow district reviews to be conducted.

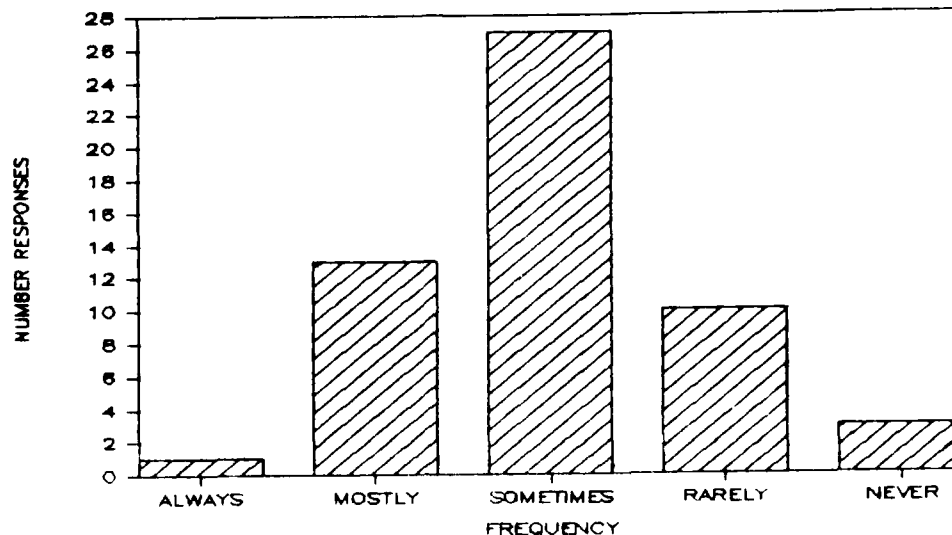
Review time sufficiency is illustrated in Table 18 and Figure 25. The numbers shown in the table are averages of responses in each project size category. An average shortfall existed of 3.1 days for small projects, 4.7 days for medium projects, and 7.1 days for large projects. The figures indicate that the time provided to do reviews fell far short of that needed given other job requirements. These numbers are supported by the qualitative responses to question 14 as shown in the figure. 74% of the respondents stated sufficient time was available only "sometimes", "rarely", or "never".

Table 18
Review Time Needed vs Review Time Available
(Questions 6, 7, and 8)

NOTE: All times shown in work days.

Project Size	Avg Time Needed for Review Only	Avg Time Needed Given Other Regents	Avg Time Available
Small	2.3	9.7	6.6
Medium	3.5	12.5	7.8
Large	6.2	16.4	9.3

Figure 25
Frequency of Sufficient Review Time (Question 14)



When asked the reasons why sufficient time was not available, the responses were as shown in Figure 26. Response choices included poor information, lack of funding, poor plans and specs, other work, short suspenses, and "other". The majority listed "other work" and "short suspenses" as the main causes of insufficient review time. This data was corroborated by responses to question 10. Question 10 asked respondents to list, in priority, their daily activities. They were asked to prioritize on the basis of the way things actually were and then to reprioritize based on the way they felt things ought to be. Each priority list was then divided into thirds. The priority of reviews was determined by determining how often they fell in the top, middle, and bottom third of each individual list. The results are

shown in Figure 27. 73% of those answering this question prioritized reviews with the middle or lower third of other things they had to do. More significantly, if given the opportunity to change these priorities, most would not increase the position of reviews. In fact, several placed them at a lower priority. This indicates that, regardless of how important reviews were felt to be, other activities are considered just as important or more so.

Figure 26
Reasons Review Time is Not Available (Question 15)

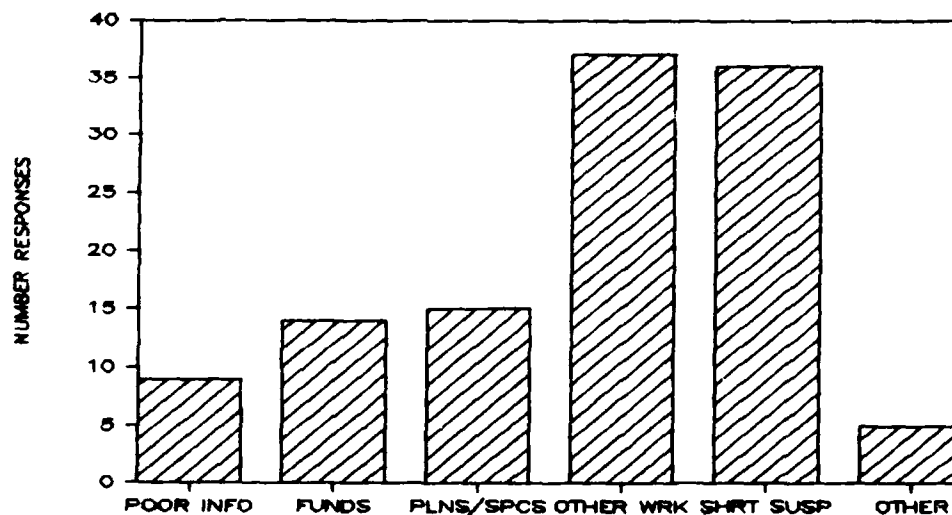
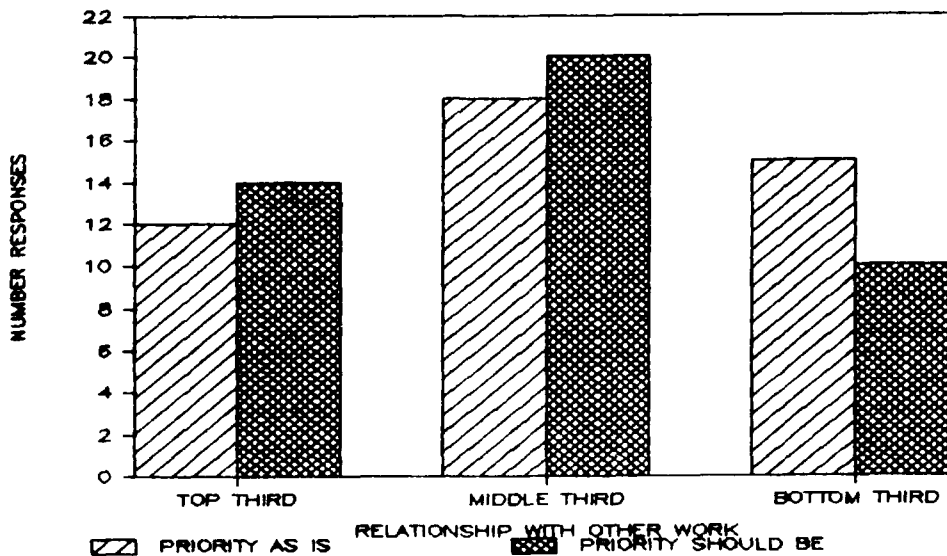


Figure 27
Review Priority - "As Is" vs "Should Be" (Question 10)



The issue of competing work raised the question of exactly what kind of work reviews were competing against. Much of it was other essential tasks, such as design, mod processing, and quality assurance. But it was suggested that there were also significant administrative tasks which also consumed large amounts of manhours. These included reports, meetings, correspondence, and other requirements which detracted from more essential, design/construction related responsibilities. Many of these requirements were thought to be unnecessary by the individuals required to perform them. The impact of outside detractors on design and review quality was beyond the scope of this study, but it is an issue deserving further study.

The district required a minimum of 51 calendar days prior to contract award for DEH designed projects to be processed through the district review system. This time included administrative processing, copying, distribution, review comment coordination, and other activities besides the actual reviews. 15 projects were traced to see if "end of year crunches" or other reasons resulted in DEH not providing plans and specifications to the district with enough lead time within which to conduct a proper review. These included ten small, four medium, and one large project. All 15 projects were found to have been provided with sufficient time to meet the 51 day requirement. The average time prior to bid opening for small projects was 85.4 days, the medium projects 86.5 days, and the one large project 105 days. Consequently, it was concluded that timely submission by DEH did not contribute to the shortage of review time.

Funding is cited in other studies as a main reason reviews are not fully conducted. However, in this study, lack of funds was seldom identified as a significant detractor. Consequently, this area was not fully explored. Review funding for MCA projects was not studied at all. For OMA projects, the DEH automatically authorizes 12 hours of technical review per needed discipline. DEH also provides up to \$1000 for constructibility reviews. Discussions with DEH and district personnel indicate that it is a relatively easy matter to obtain additional funds should this time prove insufficient for the review needed. DEH is prepared to provide a fund commitment within eight

hours of a telephonic justification for the additional funds (assuming such funds are available). However, such requests were rarely made.

It was concluded from this portion of the study that reviews were not likely to receive the priority and effort they need to adequately catch design deficiencies and site condition problems unless the review mission is conducted by individuals who have review as their first priority. This in turn implies the need to either rearrange existing priorities within the various offices now conducting reviews or establish separate constructibility and technical review cells. It is essential to controlling cost growth that one action or the other be taken.

Review Processing Procedures:

This section presents findings as to the procedural framework within which reviews are conducted. Specific issues addressed are:

1. Overall district review policy.
2. The frequency at which reviews are conducted at each stage of design, and the frequency that the same reviewer stays with a project throughout the design period.
3. The availability of previous review comments on a given project, and the frequency at which comments are checked to insure incorporation in the final design.
4. Site visits during design and review.
5. The manner in which projects are assigned to individuals for review.

The potential for review inconsistency due to lack of standardized training was discussed in a previous section. This could

be mitigated by the existence of a standard review policy to include review aids, such as checklists. However, there was no standard policy in effect at the time of the study. Although various checklists existed, they were not widely disseminated and seldom used. A comparison of checklist availability versus use is shown in Figure 28. The bars with diagonal lines indicate the frequency of availability; the cross-hatched bars the frequency of use. 27 of 51 (53%) responses indicate checklists are rarely or never available to reviewers. 25 of 47 (53%) responses indicate checklists are rarely or never used. The difference in total responses for each category was due to not all respondents answering both questions. As can be seen from the graph, checklist use generally paralleled availability. However, having a checklist on hand did not always guarantee its use, quality, or completeness. For example, four respondents claimed to always have such an aid available, but only one reported always using it. Whereas the use of checklists would not be a panacea to the overall review issue, such an aid, used as part of an overall review policy, would provide guidance on what types of items were to be checked and how reviews should be conducted.

Existing engineer regulations did not provide specific guidance on how often reviews were to be conducted. ER 1110-345-100 required at least one review upon design completion. However, the regulation stated additional reviews may be required commensurate with the complexity of the project. ER 415-1-11 required a minimum of two constructibility reviews; one at the concept stage of design and the second upon design completion within 30 days before formal advertising.

Specific policy was left up to the individual divisions and districts. The district regulation in use at the time of this study discussed reviews at the "concept", "preliminary", and "final" stages of design. DEH design reviews were supposed to be completed prior to the design being sent to district, with a final review by district upon receipt. For district in-house designs and A/E designs, reviews were supposed to be conducted at the 35%, 90%, and 100% stages of design, although this varied from project to project depending on scope of work and type of review. In some cases, reviews were also done at the 65% design stage.

Figure 28
Checklist Availability vs Use (Questions 21 and 33)

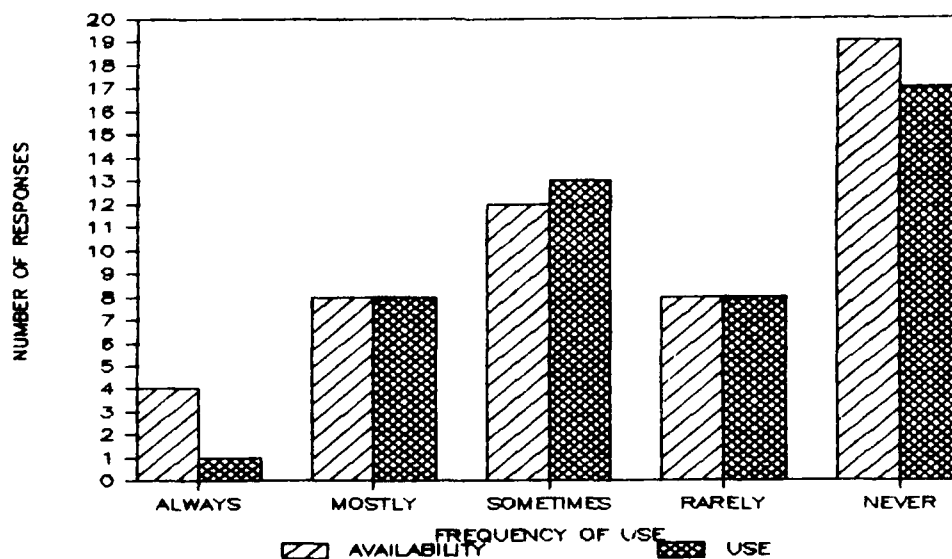


Figure 29 presents data for the frequency of reviews at each required stage for new and renovation work. Data for new work projects

is shown by the bars with diagonal lines, and renovation work by the cross-hatched bars. For new work, 55% of the respondents report reviews done at all stages either "always" or "most of the time". For renovation work, this percentage drops to 40%. Of significance in both cases is the high percentage of times when these reviews are performed only "sometimes", "rarely", or "never". The main reason for this appears to be the lack of time and/or competing work requirements as identified in the previous section.

Figure 29
Frequency of Reviews at Each Design Stage (Questions 23 and 24)
New and Renovation Work

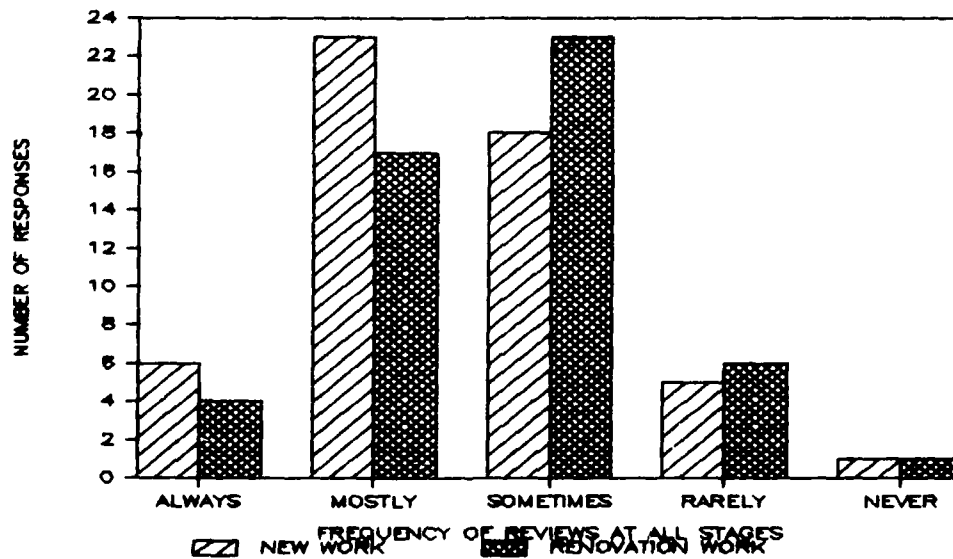
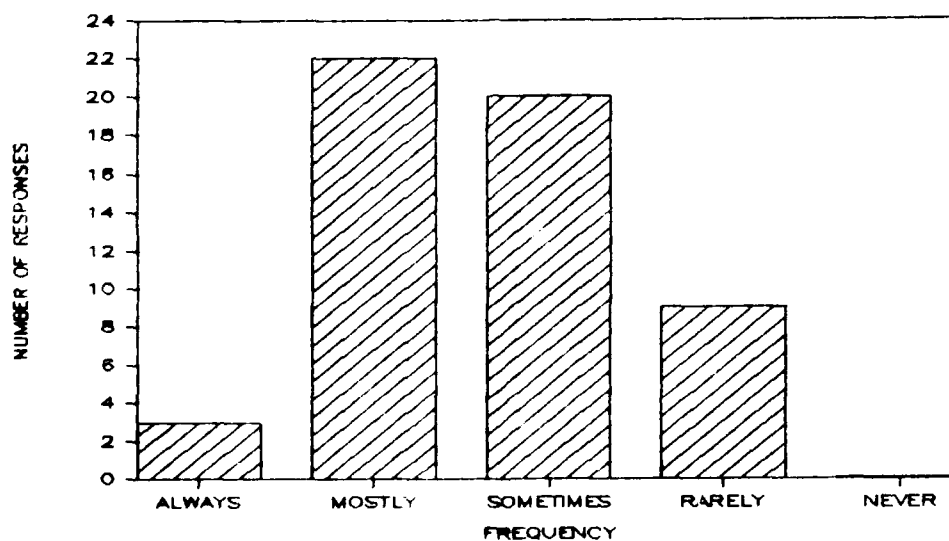


Figure 30 shows data on how often the reviews that are conducted at each stage are done by the same individual. 54% of the respondents claim that the same individual does reviews at all stages

only "sometimes" or "rarely". This, by itself, is not necessarily a major problem provided the comments of one reviewer are made available to subsequent reviewers. Furthermore, some mechanism should exist to record which items were checked and which were not by each reviewer. Without this mechanism, the potential exists for some items being needlessly reviewed multiple times while other items are overlooked altogether.

Figure 30
Frequency at Which the Same Individual Conducts
Reviews at Each Design Stage (Question 25)



Since different individuals conducted reviews at each design stage, it was essential that comments from previous reviewers be made available. The graph at Figure 31 presents the respondents view as to

how often this occurred. In the majority of cases (59%), previous comments are available "always" or "most of the time". What is significant, however, is the large percentage (41%) of instances when comments are only "sometimes" or "rarely" available. The implication is that there often was no way a problem identified in an early review could be passed on to subsequent reviewers.

Figure 31
Availability of Previous Review Comments (Question 30)

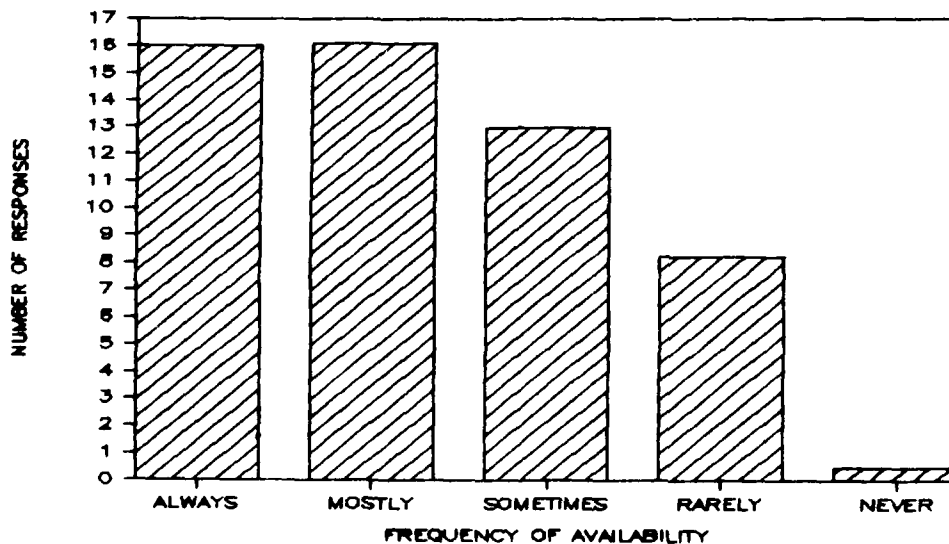


Figure 32 shows how often it was felt comments submitted by reviewers were incorporated into final design, as well as how often designs were checked to insure all valid comments were incorporated. In only slightly more than half (54%) the responses was it felt comments "always" or "most of the time" found their way into the final

product. Submitted comments were checked to insure incorporation even less frequently. 48% of the respondents stated comments are checked "always" or "most of the time". Part of the problem may be perception; as will be shown, feedback to as to whether a comment was incorporated was frequently not provided to the reviewer. It should also be noted that the final decision on incorporation rests with the project manager. A comment considered valid by the reviewer may not be viewed in the same manner by the project manager. Unsolicited comments written on the questionnaire provide another explanation. If there was not time to incorporate comments by contract amendment prior to bid opening, they may be tabled for later modification or dropped altogether. In any of these cases, it is possible that the reviewer may not have been aware of what took place.

The frequency with which feedback was given reviewers is presented Figure 33. In more than half of the responses (57%), feedback as to the quality of review comments was given only "sometimes", "rarely", or "never". This trend was seen in the responses of all respondent groups; it was not a problem isolated to any one agency. The lack of feedback, having different reviewers at each design stage, lack of overall review policy, and nonstandard training together create a serious obstacle to the conduct of consistent reviews.

Figure 32
Frequency of Review Comments Being Incorporated
Into Final Design (Questions 18 and 31)

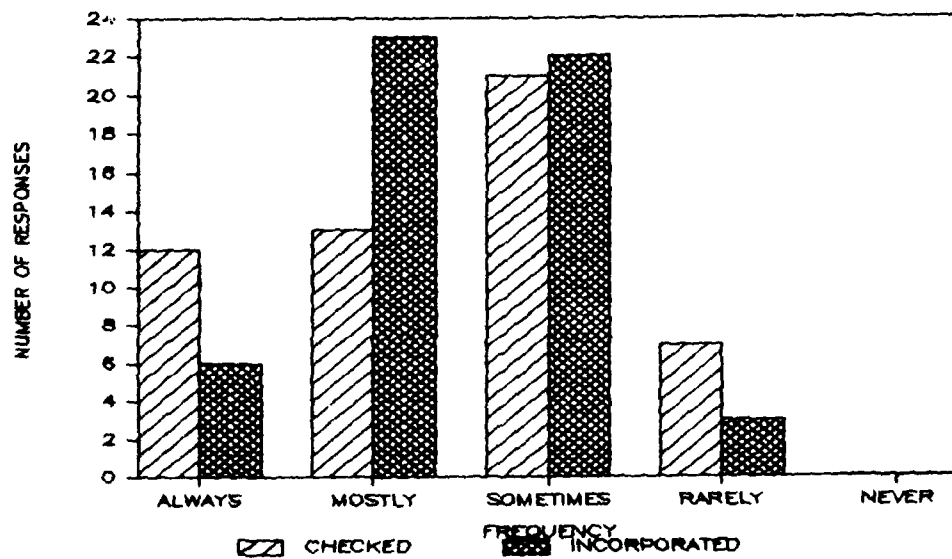
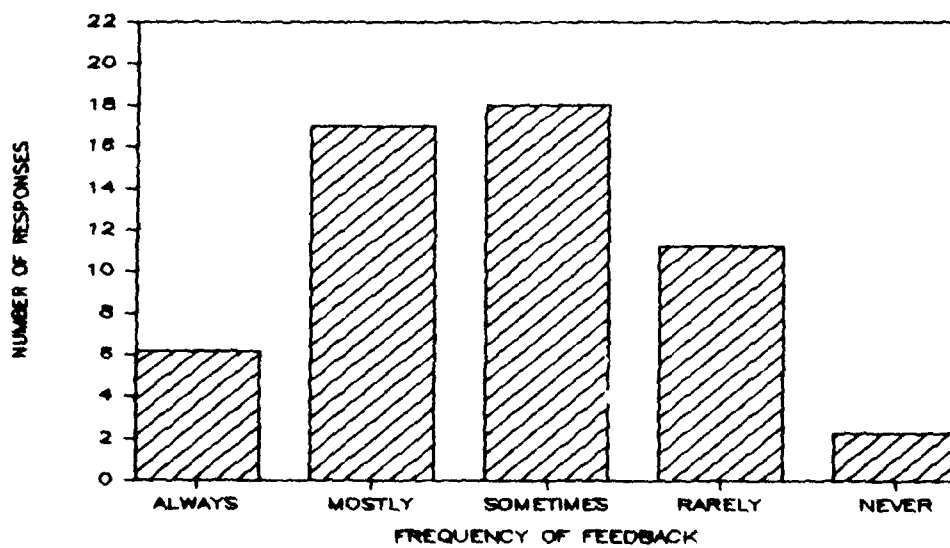


Figure 33
Frequency of Feedback Given to Reviewers (Question 32)



Unknown sited conditions accounted for almost 22% of project cost growth. This problem is greatest for DMA and AFH projects where the majority of work was done in existing structures. Projects which incorporated thorough site visits as part of the design and review process should have been able to catch many of these problems prior to construction.

The questionnaire asked for data on the issue of site visits only as they were or were not conducted during reviews. It did not address visits made by designers during design. Furthermore, not all projects necessarily need site visits. The data which follows must be viewed keeping this fact in mind. However, it is the opinion of the author that, had site visits been conducted during project design, the magnitude of the problem with unknown site conditions would not have been so great.

The District did not have a formal policy requiring site visits during design review. The frequency visits were conducted is graphically shown in Figure 34. 69% of the respondents report visiting sites during reviews less than 25% of the time. Table 19 breaks this data down by type of review. In general, those reviewers located at the District (quality assurance and technical design reviewers) were much less likely to visit the site than personnel located in the field. 83% of the respondents from quality assurance and 46% from engineering division reported they never visited a site as part of the review process. Since constructibility reviews are performed by field personnel as well as quality assurance personnel, these reviews are

more likely to have site visits than technical reviews. Even so, only three of six respondents involved with constructibility reviews reported visiting the site more than 75% of the time.

Figure 34
Percentage of Reviews With Site Visit (Question 11)

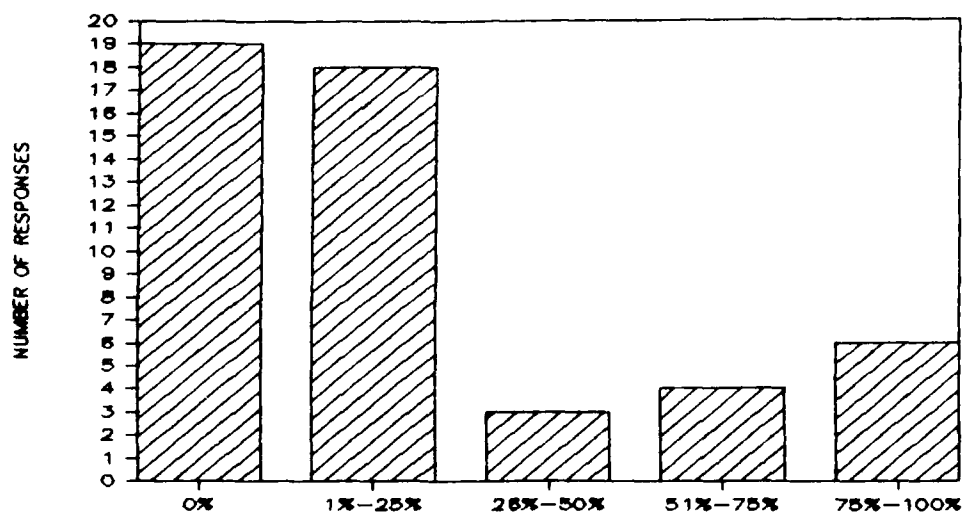


Table 19
Frequency of Site Visits
By Type of Review (Question 11)

Percentage of Times Site Visits Conducted as Part of Review					
Type of Review	0%	1-25%	26-50%	51-75%	76-100%
Technical	13	13	1	0	1
Constructibility	6	3	1	3	3

NOTE - Figures indicate number of responses in each category.

If this data is further broken down by response group, the results are as shown in Table 20.

Table 20
Frequency of Site Visits
By Response Group (Question 11)

Response Group	Percentage of Times Site Visits Conducted as Part of Review				
	0%	1-25%	26-50%	51-75%	76-100%
Engineering Div	13	13	1	0	1
Quality Assurance	5	1	0	0	0
Resident Office	1	0	0	2	1
Construction Reps	0	2	1	1	2

NOTE - Figures indicate number of responses in each category.

The groups whose respondents tended to visit the site more frequently were construction representatives and resident office personnel. However, the actual amount of time these groups had to devote to reviews was extremely limited. Responses from the questionnaires and personal interviews with the individuals concerned found that over 50% of these respondent groups placed reviews in the bottom third of their priorities. Consequently, the reviews conducted by these two groups tended to be cursory at best. The conclusions drawn from this are:

1. The top priority of work by these groups was the administration and quality assurance of ongoing construction. Given existing high work loads and staffing levels, it was probably not realistic to expect thorough reviews from either the resident office or the field construction representatives.
2. When these groups do conduct reviews, they are more likely to visit the site as part of the review process.

In the case of the construction reps, this was probably due to being located on the installation and having ready access to the project site.

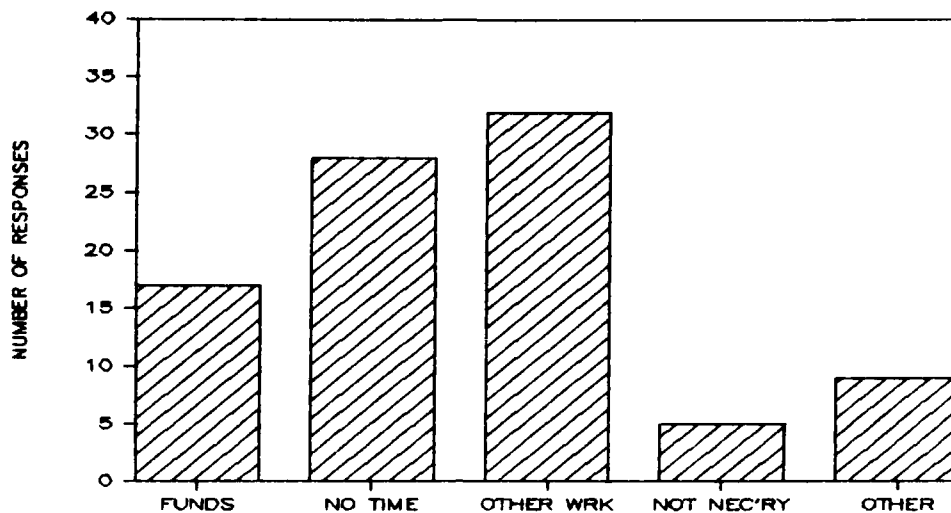
3. 35% of those conducting constructibility reviews visited the site more than 50% of the time. As has been previously shown, however, those conducting these site visits were those with the least amount of time to devote to reviews. Consequently, the primary burden for the thoroughness of constructibility reviews fell to quality assurance, a group which seldom appeared able to include site visits as part of their reviews. (This is not intended to imply that quality assurance personnel never leave their office. On the contrary; much of the QA respondents time was spent doing field inspections of ongoing construction.)

Figure 35 presents the reasons given for not visiting the site. 68% of the respondents claimed insufficient time existed to visit the site either due to competing work requirements or short suspense dates. 17% reported that lack of funding was a significant reason. The significance of this chart is that it indicates internal priorities and procedures may have more of an impact on the conduct of site visits than external factors, such as funding.

Write-in responses to the "other" category included:

1. Reviewer was not asked to visit site.
2. Site visits are conducted by the on site construction staff.
3. Site visits are a design, not construction, function.
4. Not necessary since the on-site construction staff does it.
5. Project complexity may not always warrant a site visit.
6. Construction site was too far to visit.

Figure 35
Reasons for Not Conducting Site Visits
During Review (Question 12)



Section chiefs in design branch were individually asked as to how they assigned reviews to their personnel. In most cases, it was done on a work load basis. The individual with the least amount of work at the time when the review request arrived was given the review to do. All section heads stated that an attempt was made to match the individual's expertise with the nature of the project being reviewed. An attempt was also made to give reviews of a particular project to those familiar with the project. It was admitted, however, that this was not always possible. The first priority of design branch was project design. Since it was difficult to schedule reviews with any

long range accuracy, it was likely that, given the current system, they will continue be handled on a catch-as-catch-can basis.

Respondents were asked to evaluate the overall emphasis placed by "the system" on reviews. "The system" was defined in the questionnaire as being the district, DEH, the customer, and any of the other agencies that may be involved in preconstruction reviews. The results of this question is at Figure 36. Whereas the majority (53%) feel that it is "about right", a significant portion (36%) feel that the emphasis is "not enough".

Figure 36
Emphasis on Reviews by "The System" (Question 27)

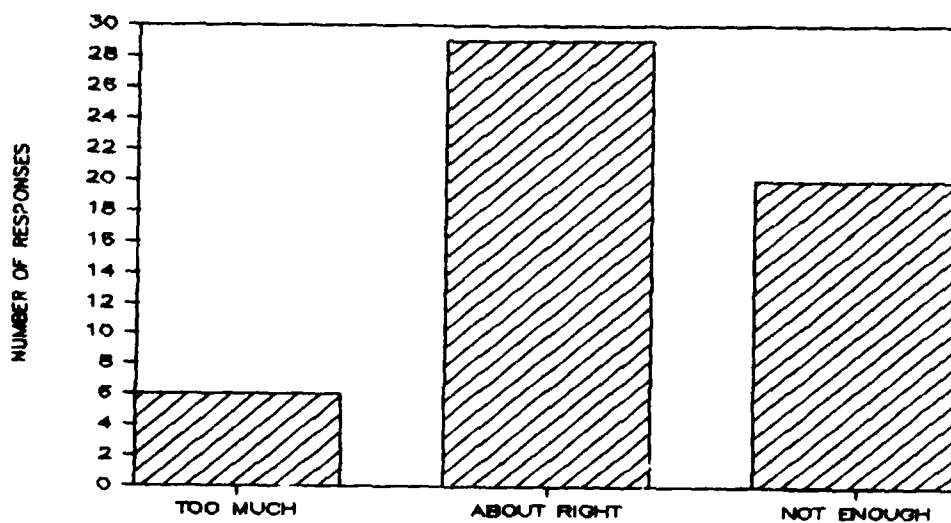


Table 21 shows how responses to the question of review emphasis varied by response group. The largest number of those who feel it is

"not enough" are those engineers in Engineering Division. An explanation for number indicating review emphasis was "too much" may lie in an unsolicited comment from the resident office. The comment stated that given the current work load required in the respondent's section, the emphasis on reviews was "too much". In other words, it was felt there just was not sufficient time to do everything and that it was not possible to meet the standard expected in properly conducted reviews.

Table 21
Emphasis on Reviews By Response Group (Question 27)

Emphasis by "The System"			
Percentage of Responses per Response Group			
Response Group	Too Much	About Right	Not Enough
Engineering Div	11%	50%	39%
Quality Assurance	0%	100%	0%
Construction Reps	17%	33%	50%
Resident Office	20%	20%	60%
Project Managers	10%	60%	30%

Summary:

The purpose of this chapter was to determine why the review system did not do a better job of controlling cost growth in the projects studied. This was done by collecting opinions of those involved with the review process, at the district level, by questionnaire. Data was collected in the areas of review personnel qualifications, time available, and procedural systems. The findings indicate weaknesses in the areas of review training, time availability

due to competing work requirements, lack of measures to insure comments are transmitted between subsequent reviewers, lack of checking to insure incorporation into final design, and the lack of an overall review policy.

CHAPTER 6

COMPARISON OF FINDINGS WITH PREVIOUS STUDIES

General:

The purpose of this chapter is to compare the findings of this study with the findings of others to determine which may be considered conclusive and which require further examination. The chapter is organized in the following manner. The next two sections identify those findings from Chapters 4 and 5 corroborated by other studies. The fourth section identifies the findings of this thesis which differ from those of previous studies. The fifth section discusses those findings examined in this study not found to be previously addressed. The final section is a chapter summary.

Most of the other papers, although related, were written to subjects other than the issues specifically addressed here. The data in these other studies were collected to support different theses. Fortunately, several authors included their raw data in appendices or tables. The methodology used in this study was applied to their data in order to arrive at a common basis of comparison. Consequently, the conclusions drawn from those calculations are not necessarily those of the author of the study from which the base data was taken.

Corroborative Findings - Causes and Costs of Mods:

Table 22 identifies the issues of Chapter 4 concerning the causes and costs of modifications. It further identifies those

findings supported by the research of others (annotated "Yes"), those findings in disagreement ("No"), and those issues not addressed in other papers ("N/A"). The remainder of this section discusses only those issues fully corroborated by other studies; conclusions of this study in disagreement or not addressed by others are discussed separately.

Table 22
Comparison of Findings - Causes and Cost of Modifications

<u>Issue Addressed</u>	<u>Findings in Agreement With Other Studies</u>
Mod Causes - by Cost	Yes
Indirect Costs	Yes
Impact on Productivity	Yes
Potential Savings	Yes
Correlation by Project Size	No
Correlation by Designer	No
Correlation by Project Type	N/A
Mod Causes - by Items of Change	N/A
Disciplines of Design Def	N/A

The most strongly supported finding was the causes of modification cost. Six studies were identified which addressed the subject. All examined federally funded projects. A comparison of findings is at Table 23. The table identifies the study, the number of projects involved (when given), and a rank ordering as to the proportion of mods caused by each source. The numbers reflect the number one most frequent cause, the number two most frequent cause, etc. The lower the number, the larger the percentage of mods found due to that cause. Two papers did not quantify the number of mods due to each source. In these cases, an "X" is used to identify causes

mentioned. The "X" signifies the cause as a major contributor to mods without a specific ranking as to its impact having been established. Each study is identified by author, if known, or title. The number in parenthesis in the first column following the identification is keyed to the endnotes at the end of this chapter.

Table 23
Comparison of Findings - Mod Causes

Causes of Modifications							
Article or Study	No. Proj	Dsgn Def	Site Cond	User Req	Dsgn Chnge	Val Engr	Remarks
Diekmann (1)	22	1	3	2	4		
Rosmond (2)	--	1		2			1
TX A&M (3)	--	1,7,9	4	10	2,10,15	12	2
USAFEK-K (4)	--		1				3
Rowland (5)	20	X	X	X	X		4
ENR (6)	269	1					5
Ballou (7)	--	X	X	X			6
CERL ARMS (8)	--	1					7
This Study	25	1	3	2	4	5	

REMARKS:

1. Quotes 1982 audit by Defense Audit Service, which lists no. 3 cause as plans and specs being incomplete at time of bid award.
2. From list of top 16 mod causes. Others were changing technology, excusable delays, user interference, lack of proper review, and administrative actions. Multiple rankings due to differences in operational definitions.
3. Concentrated on OMA projects in Korea. Identified no. 2 cause as OMA work overload.
4. Rowland did not quantify which caused the most mods.
5. Quoted GAO study of federal projects. No. 2 cause was cost estimating errors.
6. Does not specifically list design deficiencies, but does mention imprecise specification language and ambiguous drawings, both of which are included in the operational definition of design deficiency in this study.
7. Only mentions design deficiencies. Claims design deficiencies account for 56% of all mods.

These findings are conclusive. Five of the eight other studies list design deficiencies as the number one cause of contract modifications; two of the remaining three list them as a major contributor to changes. User requested changes are most frequently listed as the second and unknown site conditions as the third most common causes of mod cost. Consequently, a concerted effort to control these areas should result in significant cost growth savings.

The money that could be saved by controlling modifications was quantified in a study of constructibility reviews by Lloyd Finley. Finley studied two projects awarded by the Naval Facilities Engineering Command to determine the benefit/cost ratio between the cost of constructibility reviews and cost growth savings. It should be noted that his definition of constructibility review encompasses this paper's operational definition of both constructibility and technical design review. He calculated the costs to the government of doing the reviews and compared those figures with the amount the government might have paid if the errors discovered during the review had gone to construction. His findings are shown in Table 24. His findings reinforce the conclusion of this study that it is less expensive to identify and correct problems before contract award than after. (9)

Table 24
Benefit/Cost Analysis of Constructibility Review
(Finley's Study)

Project No.	Benefit to Cost Ratio (10% mark-up)	Benefit to Cost Ratio (2% mark-up)
1	28.4	2.8
2	6.8	1.5

Although not quantified, these findings are qualitatively echoed in several other papers. The Texas A&M Research Foundation found:

"...the work accomplished by change orders and modifications is always more costly than similar work in the basic contract, and requires additional effort..." (10)

The Blue Ribbon Panel on Management of Construction Quality stated:

"...just one less change order per contract, resulting from improved customer-Corps communications will produce substantial Corps-wide savings." (11)

Harvey Kagan discovered an additional way modifications may increase project costs. In an article for the American Society of Civil Engineers' Journal of Professional Issues in Engineering, he cites an argument used by contractors to justify additional compensation. (12) Kagan states that contractors expect a certain number of modifications to be "normal" for a given type project. If the number of mods in a project exceeds the norm, contractors may ask for impact costs due to the amount of time spent preparing change order paperwork and estimates. In essence, their argument is that processing excessive numbers of modifications disrupts their work schedule and causes additional expenses, for which the government is responsible. In other words, the indirect costs of modification processing incurred by the contractor are passed on as direct cost to the government. Reducing the number of mods should reduce this source of cost growth as well.

There was also consensus among the studies as to the impact of modification processing on productivity and Corps indirect costs. Although none of the other studies attempted to quantify effort spent

on mods, several offered qualitative conclusions based on their research. The Texas A&M Research Foundation concluded:

"The chief mission of the Corps is to turn out good construction. If dollars, manhours, and talent have to be diverted from the chief mission of good construction to the issuance of contract modifications,...then the chief mission of good construction must suffer." (13)

and:

"Fewer change orders would reduce administrative cost and permit assignment of more manpower to inspection and construction problems which are of real primary importance." (14)

In his study on constructibility reviews, Lloyd Finley wrote:

"It should be recognized that any time "spent" by management in resolving conflicts that could reasonably have been caught prior to award, is time that might be more efficiently and effectively utilized on other related contract activities." (15)

It may therefore be concluded that modification cost is not limited to direct construction cost, and that significant savings can be realized through thorough preconstruction reviews. In addition to direct construction cost, the Corps pays for the lack of good reviews in terms of administrative overhead, effort, and lower productivity. These costs are real, even if they cannot always be quantified.

Corroborative Findings -- Design Review System:

Preconstruction reviews were the subject of numerous other studies. Recall this study addressed technical and constructibility reviews from the issues of personnel qualifications, time available, and procedural framework. Table 25 lists the specific issues examined

under each of these categories and identifies those corroborated by other studies. "Yes" indicates corroborating findings from at least one other study with no studies in disagreement; "No" indicates one or more studies in disagreement; and "N/A" indicates issues not addressed in other papers. Supporting studies are specifically discussed in the paragraphs which follow. Findings from other studies not in agreement with those of this study are discussed in the next section.

Table 25
Comparison of Findings - Design Review Process

Issue Addressed-----	Findings in Agreement With Other Studies
Cross Training	Yes
Competing Work Requirements	Yes
Project Scope Definition	Yes
Site Visits	Yes
Reviews at Each Stage of Design	Yes
Same Individual does all Reviews	Yes
Coordination of Comments	Yes
Incorporation of Comments	Yes
Need for Overall Policy	Yes
Use of Checklists	Yes
Need for Reviews	Yes
Destructive Testing	Yes
Reasons Sites not Visited	Yes
Need for Separate Review Cell	Yes
Feedback Given Reviewers	N/A
Formal Review Training	N/A

Two studies addressed the issue of cross training between design and construction personnel. The Corps of Engineers Blue Ribbon Panel report stated:

"Procedurally, there is a need to improve consultation with field engineers in the design process of major projects. Likewise, there is a need to improve design participation in the actual construction process." (16)

The report goes on to say:

"There is insufficient cross-training [sic] and joint experience among engineering division and construction division professionals." (17)

The second report, prepared by the Texas A&M Research Foundation, recommended one manner in which problems with inadequate or incomplete designs could be corrected would be to "give designers field experience in the administration of construction contracts." (18).

The findings of this study reinforce the conclusions of the Blue Ribbon Panel and the Texas A&M Research Foundation. The professional capabilities of designer and constructor would be significantly enhanced if each had some experience in the field of the other.

Table 26 presents the major review problems identified in this study and identifies how often those problems appear as major causes of poor reviews in other studies. The first column identifies the study, along with a key to the endnotes at the end of the chapter. The priority given by each author to each problem as to its relative importance in weakening the review process is shown. Those problems not rated in relative importance are marked with an "X".

The four most often cited problems are lack of time due to peak work periods/competing priorities, poor scope definition, lack of site visits, and uncoordinated review comments. These problems have been cited by independent researchers, Corps of Engineer panels, and members of private A/E firms involved in government work. The problems of multiple reviewers, coordination of review comments, and incorporating comments into final design are also often mentioned other studies.

Table 26
Comparison of Findings - Problems in the Review Process

Causes of Review Problems						
Study	Time/ Other Work	Proj Scope Def	Site Visits	Same Reviewer Each Stage	Comment Coord	Rmks
TX A&M (19)	2	1	X		9	1
TX A&M (20)	X	X				2
Dsgn Forum (21)		X	X	X	X	3
Grn Ribbon (22)					X	4
This Study	X	X	X	X	X	

REMARKS:

1. From list of top ten review problems. Other design review problems included unnecessary reviews, poor cost estimates, and poor quality of A/E work. Study also addressed inadequate coordination with using agency and lack of proper site investigation.
2. This was a subsequent A&M study. Other causes included insufficient information to A/E, unnecessary reviews, and budget cycle.
3. Also cited use of checklists, unrealistic fee structure, and lack of proper as-built drawings.
4. Study emphasized customer involvement in reviews and only generally discussed need for quality review.

These issues were frequently cited by participants in the Design Quality Forum as detractors from project quality (23), as well as the Green Ribbon Report (24) and Texas A&M's May 1968 study (25). It may therefore be concluded that the problems with the review system identified in this study are not unique to the sample from which the data were collected. It is further concluded that all of these areas need to be addressed if efficient reviews are to be conducted; attacking only one or two by themselves will not correct the problem. What is needed is an all encompassing review policy within each

district specifying procedures to insure the impact of these problems is minimized. The "Corps needs to encourage Districts to quantify technical criteria for projects and establish a policy of rational, analytical review." (26).

The advantages of using review checklists were cited in several studies. The most frequently referenced checklist system was the Navy's "Redicheck". "Redicheck is a structured review system which provides a logical and orderly approach to checking construction drawings at the 100% design stage." (27) Redicheck was favorably referred to by Finley (28) and participants in the South Atlantic Division's Design Quality Forum (29). Checklists, however, should not be considered a panacea. They need to be incorporated with overall review policy and procedures. The advantages of using a checklist are that it facilitates review continuity (especially when reviews are conducted by different people at different stages of design) and it provides a logical, consistent review methodology.

The importance of reviews in producing quality construction projects and reducing cost growth is acknowledged or implied in each of the studies surveyed. Finley's analysis of review cost versus project cost was previously cited. In his study of the contractor quality control system, Henry Turowski stated:

"The design review has been called by some to be the most important tool for developing inherent quality or reliability in a product." (30)

Kagan, in his article, emphasizes the need for review to coordinate drawings between different design disciplines. He warns:

"If the coordination of drawings is first performed by the contractor, the cost will be considerable more." (31)

The Corps apparently shares this philosophy, as witnessed by the regulations requiring reviews be performed prior to bid advertisement. At the functional level, however, this guidance appears to be frequently not complied with. Furthermore, this problem has been identified before, with seemingly little progress made in correcting it. Extracts from the Texas A&M Research Foundation's 1968 report state:

"An extremely high percentage of plans and specifications are published each year which are inadequate due to conflicts or errors...
...it is necessary to advertise projects for bids with insufficiently prepared plans...
...the only effective review period is during advertisement...
...comments of using service and other interested parties frequently are received too late to incorporate in the advertised project." (32)

Yet 17 years later, the Green Ribbon Panel found "Procedures to provide quality design review...need strengthening." (33) Specific weaknesses noted in other studies (most of which were completed since 1980) were previously referred to. Thus, despite publication over the years of numerous regulations, engineering pamphlets, studies, reports, and manuals, many Districts still fail to effectively manage one of the most important tools for controlling project cost growth.

In addition to direct cost, indirect cost, and lower productivity, the Corps pays for poor review procedures in two other areas as well; customer satisfaction and professional reputation. It was suggested in Chapter 4 the reason for the high percentage of user

requested changes was failure to properly define project scope during design. Installation involvement during the initial stages of design is essential to insure the needs and desires of the customer are integrated into the project. Failure to involve the customer can lead to a deterioration in the working relationship between District and DEM and lower design quality. In 1983, the Blue Ribbon Panel stated:

"During construction, the Corps must employ better techniques to assist the customer/user in understanding the project's progress and how the project compares with his original expectations. The process of responding to customer/user inquiries must also be improved." (34)

This conclusion was echoed in the 1985 report of the Green Ribbon Panel:

"...there is ample evidence to support the perception that the DE [District Engineer] does not fully involve his customers during the design process. The most widespread comments include: lack of opportunity to participate in the design reviews, slow response to requests, poor feedback on design review comments, claims of failure to consult the customers on problems and perceived lack of concern by the DE over customer needs." (35)

Although input from the installation is essential, it should be limited to the functional aspects of the project, and not include technical design or construction techniques. The 1968 Texas A&M Research Foundation study found that unnecessary reviews by the customer, particularly when they include reviews of technical design, were one of their top ten design review problems. (36) Their 1969 report was more specific:

"The Corps of Engineers needs [to adopt] a procedure wherein only the functional aspects of the design are presented to the User [sic] for review..." (37)

The primary reason for controlling customer input to the review process

is the cost and time that may be lost reconciling their comments with those of district reviewers. This problem may be aggravated by different interpretations of design criteria, preferences in material or construction methods, or differing opinions on architectural aesthetics. Thus, it may be concluded that customer interface is essential for improving user satisfaction, understanding the installation's expectations, and defining project scope. Once the project scope has been determined, however, decisions on technical design and construction methods to meet those requirements are best left to the supporting district.

It is obvious that excessive cost growth, numerous modifications, and failure to address user concerns will hurt the Corps' professional reputation with the customer. That reputation may also be damaged within the greater engineering professional community, particularly with the reliance placed on private A/E firms to design many Corps projects. Perceptions held of the Corps' by several A/E firms, although not specifically mentioned, can be inferred from comments made during the South Atlantic Division's Design Quality Forum. The objective of the forum was to identify the significant things that adversely affect the quality of the product private A/E firms provide the Savannah District. Frequently cited complaints included poor definition of project scope; failure to edit, coordinate, and consolidate design review comments; an inflexible fee structure which does not compensate for predesign conferences or site visits; and loss of continuity when the district has different reviewers at each stage. One participant stated it costs 30-40% more to do Corps work

than commercial work because of the tendency to stop and start work and the time it takes A/E's to respond to review comments. (38) These and other problems closely parallel the issues raised in this and other studies. Consequently, it may be inferred that the opinions held by the forum's participants would be shared by A/Es facing similar circumstances in other locations.

The final area of general agreement was the use of separate review teams as a means to address problems with the conduct of reviews. Two studies supported the position taken in this paper that separate review cells are needed to insure reviews get the priority they need to be effective. The first the 1968 Texas A&M Research Foundation report which concluded such a cell would contribute to providing more complete reviews of plans and specifications. The report states:

"It is possible that a reorganization of units in the Engineering Division, with a special group set up specifically to review plans and specifications, is a preferred sequence." (39)

In his study of contractor quality control on Navy projects, Turowski concluded many potential problems could be eliminated by setting standards for design quality and thoroughly reviewing all aspects of the plans and specifications. He further stated:

"To do this correctly, the Navy would be required to invest a considerable amount of its EFD talent into the formation and operation of design review teams. These teams, composed of experts in each aspect of the project, would review the potential contract in far more depth and detail than is presently being accomplished. A review conducted in this manner would not only clear up design problems before they became construction problems, but would also alert the [contract A/E] designers that the Navy is interested in complete, quality designs. (40)

The creation of a separate review cell does not imply completely divorcing review from design. These functions are closely intertwined. The review team should be located within Engineering Division to facilitate communications between designer and reviewer. But it seems essential that different individuals perform these tasks. It is unrealistic to expect reviews to receive the priority needed to be effective if forced to compete with other essential tasks.

Contradictory Findings:

Two findings of this study were found to be in substantial disagreement with the findings of one or more other studies. These were the correlation of cost growth by project size and the correlation of cost growth by designer.

The issue of mod cost and project size was addressed by the Diekmann-Nelson study and in Henry Rowland's masters thesis. Table 27 compares the data of their studies with the data of this study. It should be noted that the methodologies they used differed from the methodology used here. In order to make a meaningful comparison, the data from their studies had to be recomputed using the methodology of this study. Consequently, the figures shown in Table 27 do not necessarily reflect the calculations of these other authors.

The findings of this study, expressed in Chapter 4, was that smaller projects tended to register higher levels of cost growth. This was not the trend established in the other two. Diekmann's data shows no discernable trend; Rowland's indicates that cost growth rises as projects become more expensive. It is therefore not possible to draw

meaningful conclusions concerning cost growth and project size until further research on this subject is conducted.

Table 27
Comparison of Findings - Cost Growth as Function
of Project Size

Diekmann-Nelson Data (41)

Project Size (\$000)	No. Proj	Total No. Claims	Cost Growth	Avg. Cost Per Claim
Less Than \$1,000	7	34	3.9%	\$ 5,000
\$1,000 - \$5,000	9	128	6.5%	\$16,000
More Than \$5,000	6	151	6.0%	\$26,000

Rowland Data (42)

Project Size (\$000)	No. Proj	Total No. Claims	Cost Growth	Avg. Cost Per Claim
Less Than \$1,000	4	42	6.2%	\$ 3,400
\$1,000 - \$5,000	11	187	7.7%	\$11,700
More Than \$5,000	4 (NOTE)	87	8.9%	\$31,100

NOTE: Rowland originally studied 20 projects. He deleted one, however, as it had too many change orders and would lead to a false interpretation of data.

This Study

Project Size (\$000)	No. Proj	Total No. Claims	Cost Growth	Avg. Cost Per Claim
Less Than \$1,000	19	96	10.5%	\$ 7,600
\$1,000 - \$5,000	6	88	3.5%	\$ 7,600
More Than \$5,000	0	0	-	-

Both of the other studies considered the number of modifications per project to be a significant indicator. Rowland used the average number of mods per project by size category as an indicator

of complexity. The Diekmann-Nelson study used the average cost per mod for the same purposes. A comparison of the average cost per claim in each study shows a general trend toward higher cost mods in larger projects. However, it is the opinion of this author that this is not really meaningful, since the number of items of change which may be incorporated into a single mod is not taken into account. Both of the other studies address the issue of multiple change mods, but neither quantify the number of changes per mod each of their projects experienced. Had they done so, a meaningful comparison between the cost per item of change could have been made in each of the size categories. As it is, no such comparison is possible.

The Diekmann-Nelson study also addressed the issue of design by in-house versus contracted A/E firms. A comparison of findings is at Table 28. Although the cost growth for A/E designed jobs is fairly close for both studies, there is significant variation in the cost growth for projects designed by government in-house personnel. This is possibly due to differences in local policies and procedures, although more study of this issue is needed before definitive conclusions can be drawn.

The conflicting findings of these studies indicates that data collected to date on the issues of cost growth as a function of project size and design agency is insufficient to make any generalizations. Further research is needed, at differing locations, before definitive conclusions on the impact of design agency on cost growth can be reached.

Table 28
Comparison of Findings - Cost Growth as Function
of Designer

Diekmann-Nelson Data (43)

Designer	No. Proj	Proj Amount (\$000)	No. Claims	Total Claim Cost (\$000)	Cost Growth
In-House	8	\$14,860	89	\$1,570	10.6%
Contract A/E	14	\$89,040	224	\$4,560	5.1%

This Study

Designer	No. Proj	Proj Amount (\$000)	No. Claims	Total Claim Cost (\$000)	Cost Growth
In-House	5	\$14,860	27	\$ 416	2.8%
Contract A/E	19	\$20,354	225	\$ 1,201	5.9%

Findings Not Addressed in Other Studies:

Five issues were examined in this study that were not found in any of the others. These issues were:

1. Causes of modifications by items of change.
2. Cost growth as a function of project type.
3. Disciplines which contribute most to design deficiencies.
4. Impact of failing to provide feedback to reviewers as to the disposition of comments made during reviews.
5. Impact of formal training of review personnel on review consistency.

Consequently, the conclusions drawn are made within the context of the study sample. As with those issues in disagreement with previous

findings, additional study in these areas is needed before definitive conclusions can be drawn.

Summary:

This chapter compared the findings of Chapters 4 and 5 with those of previously completed studies, reports, articles, and theses. Most of the findings of this study were corroborated by one or more other papers. This corroboration lends external validity to the methodology and findings of this study. On many of the corroborated issues, the findings may be considered conclusive. Seven issues, however, were found where findings were either in disagreement with previous studies or not addressed. Conclusions reached in these areas are therefore tentative and subject to verification by further research. The next chapter summarizes these conclusions and specifically identifies recommendations for continued study.

Endnotes - Chapter 6

1. James A. Diekmann and Mark C. Nelson, "Construction Claims: Frequency and Severity", Journal of Construction Engineering and Management, (Vol. 111, No. 1, March 1985), pp 75-77.
2. James R. Rosmond, "Analysis of Low Bidding and Change Order Rates for Navy Facilities Construction Contracts", (Master's thesis, Naval Postgraduate School, Monterey, June 1984), p. 28. Rosmond quotes a 1982 audit by the Defense Audit Service; the main thrust of his thesis is the manner in which contractors attempt to increase their profits through change orders.
3. Texas A&M Research Foundation, "A Systems Approach to Design and Construction for the Corps of Engineers", (TR 68-041, College Station, Texas, May 1968), pp. 142-143.
4. USA-CERL, "Ways to Improve Construction Contract Modification Processing: USAFEA Korea Case Study", (CERL Technical Report P-85/11, May 1985), page 8.
5. Henry J. Rowland, "The Causes and Effects of Change Orders on the Construction Process", (Master's thesis, Georgia Institute of Technology, School of Civil Engineering, November 1981), pp. B-I - B-III.
6. "Design Changes: The Largest Cause of Overruns", Engineer News Record, (March 6, 1975), page 10. Short article which reports findings of a GAO study of 269 federal projects. Not all projects were managed by Corps of Engineers. Other management agencies cited included Bureau of Reclamation, Federal Highway Administration, and General Services Administration.
7. L. Dennis Ballou, "Productivity Improvement", The Military Engineer, (Vol. 77, No. 503, Sept-Oct 1985), pages 484-487.
8. USA-CERL, "Automated Review Management System", Users Manual, 3 May 1985.
9. Lloyd S. Finley, "Examination of the Constructability [sic] Review in Government Contracting", (Master's thesis, Purdue University, School of Civil Engineering, 3 August 1984), pages A-I-11 and A-IV-13.
10. Texas A&M Research Foundation, May 1968, page 143.

11. Corps of Engineers Report of the Blue Ribbon Panel on "Management of Construction Quality in the U.S. Army Corps of Engineers", (Office of the Chief of Engineers, March 1983), page 2.
12. Harvey A. Kagan, "How Designers Can Avoid Construction Claims", Journal of Professional Issues in Engineering, (ASCE, Vol. 111, No. 3, July 1985), page 103.
13. Texas A&M Research Foundation, May 1968, page 112.
14. Texas A&M Research Foundation, May 1968, page 143.
15. Finley, page 5.
16. Blue Ribbon Panel, page 12.
17. Blue Ribbon Panel, page 14.
18. Texas A&M Research Foundation, May 1968, page 149.
19. Texas A&M Research Foundation, May 1968, pages 128-129 and 199.
20. Texas A&M Research Foundation, "Systems Analysis of Corps A/E Design Engineering", (College Station, Texas, June 1969), pages 41-49.
21. Corps of Engineers South Atlantic Division, "Minutes of the Design Quality Forum", (Savannah District, 3 September 1985). Forum was attended by members of the Corps of Engineers and civilian design firms contracted for work by the Savannah District. Purpose of forum was to identify the most significant things which affect the quality of the product private A/E's provide the Corps.
22. Corps of Engineers Report of the Green Ribbon Panel on "U.S. Army Corps of Engineers Support to Army Installation Commanders", (Office of the Chief of Engineers, March 1985), page 11.
23. Design Quality Forum Minutes, pages 2, 4, and 6-9.
24. Green Ribbon Panel, page 11.
25. Texas A&M Research Foundation, May 1968, page 110.
26. Texas A&M Research Foundation, June 1969, page 19.
27. William I. Nigro, "Redicheck: A System of Interdisciplinary Coordination", reproduced from DPIC Communique, (Design Professionals Insurance Company, April 1984), page 1 of 4.
28. Finley, page 18.

29. Design Quality Forum Minutes, pages 8 and 10.
30. Henry J. Turowski, "Contractor Quality Control", (Master's thesis, Naval Postgraduate School, Monterey, December 1980), page 114.
31. Kagan, page 104.
32. Texas A&M Research Foundation, May 1968, pages 143-144.
33. Green Ribbon Panel, page 11.
34. Blue Ribbon Panel, page 4.
35. Green Ribbon Panel, page 11.
36. Texas A&M Research Foundation, May 1968, pages 130 and 134-135.
37. Texas A&M Research Foundation, June 1969, page 19.
38. Design Quality Forum Minutes, pages 2-9.
39. Diekmann and Nelson, pages 76-79.
40. Rowland, appendices B and C.
41. Diekmann and Nelson, page 79.
42. Texas A&M Research Foundation, May 1968, page 149.
43. Turowski, pages 114-115.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

General:

This chapter summarizes the study's findings, conclusions, and topics recommended for further study. Those findings supported by other studies are considered conclusive unless otherwise noted. Findings which differ from those of other studies, or concern issues not previously addressed, and which will require further study before definitive conclusions can be reached are so identified.

Causes of Modifications and Cost Growth:

The major causes of modifications and cost growth in military construction projects are design deficiencies, user requested changes, and unknown site conditions. Whereas there may be local variances to this general conclusion (as noted in the USAFEA Korea case study (1)), almost every previous study which examined this issue cited one or more of these reasons as primary problem areas. Furthermore, the impact of these problems can be directly reduced by thorough and complete preconstruction design reviews.

The findings of this study indicate that the two design disciplines wherein most design deficiencies occur are architectural (57.5%) and mechanical (23.6%). Civil, electrical, and structural problems together account for the remaining 18.9%. Consequently, if the emphasis of review was placed on architectural and mechanical items

of design, significant cost growth reduction could be achieved. This conclusion, however, is based on the findings of this study alone and therefore must be considered tentative until further research on this topic is conducted.

Cost of Modifications:

The Corps of Engineers pays for modifications in five ways: direct construction costs, indirect administrative and overhead costs, lower productivity, reduced customer satisfaction, and loss of professional reputation. Direct costs are the most visible, as they are seen in the dollars actually paid to the contractor for contract changes. Fewer modifications would result in a direct, quantifiable reduction in cost as measured in spent dollars.

The impact on indirect costs and productivity is more subtle. Districts operate with relatively fixed staffing levels. The work of modification design, negotiation, and administrative processing must be accomplished by the same people responsible for project design, contract administration, design review, quality assurance, and construction inspection. Consequently, the processing of modifications must be done at the expense of these other critical functions. This can result in a cycle (as was observed in the resident office during this study) whereby the quality of review suffers because those responsible for review are swamped by more immediate requirements to process mods and day-to-day construction functions. This lower design and review quality then results in modifications to future projects. The processing of these additional mods in turn impact on the ability

to conduct future reviews, and so on. The district finds itself reacting to mods as they occur instead of acting to minimize their occurrence. Reducing the number of mods to be processed would improve productivity by freeing effort that could be concentrated on improved design and review of future projects and quality assurance of ongoing construction.

Even less quantifiable than productivity is the cost of customer dissatisfaction. The findings of the Green Ribbon Panel indicate this problem is more a function of the manner in which reviews are conducted than the number or cost of mods incurred. In the report, installations were described as feeling that districts often do not sufficiently involve installations in the review process, do not heed review comments, and are generally insensitive to customer needs. This in turn can result in increased numbers of user requested changes as construction progresses and it becomes apparent that the facility being built may not meet the use the customer intended or perceived. This situation is not always the fault of the Corps. Even a project which received a full using service review during design can have changes made during construction due to turnover of personnel within the using agency or changed requirements. But having the customer involved from the beginning can go a long way to reducing the number of mods and the potential for negative feelings that may be generated on both sides when such changes become necessary. Installation involvement should be limited to definition of project scope and functional design review, begin at the concept stage of design, and continue (at the functional level) through subsequent reviews. Comments on technical design

issues, materials, construction techniques, etc. should be left to the District.

Like customer satisfaction, the issue of the Corps' reputation within the professional engineering community seems more a function of the manner design and reviews are handled than the number of modifications produced. Comments expressed during the South Atlantic Division's Design Quality Forum cite problems with coordination of review comments, lack of funding for site visits, poor project scope definition, and lack of continuity in design review. A member of one participating A/E firm stated it costs "30-40% more to do Corps work than commercial work because of the tendency to stop and start work and the time it takes to respond to comments." (2) This cost is of course passed on to the government. Providing a smooth, efficient design-review system would help diminish these problems and enhance the Corps' overall reputation.

The conclusions drawn regarding mod impact on productivity, customer satisfaction, and professional reputation are drawn from limited sources and must therefore be considered tentative until further study is made. Future studies should attempt to quantify the impact these areas have on district overhead, design and review quality, and customer relations.

Impact of Reviews on Modifications and Cost Growth:

Technical, constructibility, and using service reviews have a direct impact on reducing modifications and cost growth. These were Projects receiving all three of these reviews were found to have

overall lower cost growth (4.7%) than projects not receiving all reviews (15.4%). Additionally, there was a lower percentage of cost growth due to design deficiencies for projects fully reviewed. However, the data indicates that review practices may not always provide a consistent quality of review for all projects. Of the 21 projects receiving all three reviews, nine (43%) still had unacceptably high levels of cost growth. Furthermore, reviews conducted on the projects studied did not adequately anticipate site condition problems and user requested changes. It is therefore concluded that:

1. In general, reviews reduce cost growth.
3. All three types of review are essential. Failure to conduct any or all of them can result in significant cost growth.
2. In order to be effective, reviews must consistently be conducted in a systematic and coordinated manner.

An attempt was made to determine review cost effectiveness. However, accounting procedures in practice at the district from which this data was collected did not record amounts or time spent on review for each project. One study, Finley's, was found where a benefit/cost analysis was conducted on constructibility reviews on Navy projects. Although the results indicate an excellent return on investment for review time, the findings must be considered tentative as they were drawn from only two projects. Additional study, using Finley's methodology, is necessary to reach a definitive conclusion. It is recommended such a study be conducted for reviews at each stage of design, in order to determine a "break even" point between reduced cost growth and unnecessary review.

Impact of Project Type on Modifications and Cost Growth:

OMA and AFH projects were found to experience higher levels of cost growth than MCA projects. OMA and AFH projects tend to be less expensive and do not appear to receive the same quality of preconstruction reviews as the higher-priced MCA projects. MCA projects, on the other hand, seem to be more thoroughly reviewed and consequently have a lower percentage of their adjusted contract amounts spent on modifications. This is somewhat understandable, since MCA projects tend to be more expensive and each percentage point of cost growth represents a higher dollar amount than a corresponding increase in growth for an OMA or AFH project.

But where OMA and AFH projects have a lower impact on dollar cost, they may have a much greater impact on customer satisfaction. Most projects ongoing at the installation studied were OMA and AFH funded. Often they were constructed under conditions of joint occupancy, where the user was still occupying the facility being worked on. Consequently, these projects had much greater customer visibility than MCA projects which tended to be isolated and under Corps control. It seems customers in general have a higher regard for the way the Corps manages MCA projects than they do OMA/AFH projects. This may be due to the fact the customer is more insulated from day to day problems on larger projects than those where facilities are shared. It is concluded that greater attention must be paid to these smaller projects in order to improve customer relations and enhance the product provided the installation by the Corps.

This finding is tentative, however, since no other studies were found which addressed the issue of cost growth as a function of project type. Additional research in this area is needed. Recommend such a study concentrate not only on cost growth but also the perceptions of the customer as to which types of project seem to be the more efficient.

Impact of Project Size on Modifications and Cost Growth:

The issue of project size is closely related to the issue of project type, since OMA and AFH projects tend to be smaller than MCA projects. The findings of this study indicate high-cost projects experience lower percentages of cost growth than do smaller projects. This finding, however, does not agree with the findings of other studies. The Diekmann-Nelson data shows no correlation between cost growth and size, whereas the Rowland data indicates cost growth increases with increasing project size. These differences could be due to varying local practices and conditions, or it could be that the data base is just too small from which to determine general trends. In either case, this is an area requiring additional study before general conclusions may be drawn. The close relation of project size to project type would indicate that perhaps one study could address both issues.

Impact of Design Agency on Modifications and Cost Growth:

Like the issue of project size, the findings of this study concerning cost growth and design agency differ from the findings of

the only other study found which addressed this area. Data from the Diekmann-Nelson study indicates cost growth for projects designed by contracted A/E firms (5.1%) is significantly lower than projects designed by in-house government engineers (10.6%). The results of this study, however, show just the opposite. The cost growth of A/E designed projects (5.9%) is higher than those of in-house designed projects (2.8%). It is interesting to note that the cost growth of A/E projects for both studies is roughly equal (5.1% to 5.9%). The differences in the figures for in-house design may be due to different local procedures and practices within the respective districts studied. It may tentatively be concluded that A/E designed projects can expect 5-6% cost growth, while cost growth for in-house designs will vary depending on local conditions. These conditions may include review policy, design policy, relationships with the supported installations, internal procedures, the proximity of the designer to the project for site visits, and work load. The issue of design agency and cost growth, however, is another area requiring further study before definitive conclusions may be reached.

Qualifications of Review Personnel:

The personnel performing technical and constructibility reviews on the 25 projects included in this study generally possessed the requisite education, training, and experience to conduct good reviews. Those responsible for technical review tended to have more education and experience in technical design. Many held professional certification within their design fields. Those responsible for

constructibility reviews had less formal education, but much greater practical experience, especially in construction. Almost everyone was convinced good reviews saved the government money and should be conducted for all types and sizes of projects. Consequently, poorly qualified individuals or people with poor attitudes toward reviews can be eliminated as major causes of problems with the system used to review the projects of this study.

Two potential areas of weakness were found. The first was the lack of construction experience among those doing technical reviews and the lack of design experience among those doing constructibility reviews. It would be a distinct advantage for someone designing (or technically reviewing) a project to have some experience in how that project would be constructed. Similarly, it would be advantageous for the individual doing constructibility reviews to have some experience with technical design. This cross training was noticeably absent from the personnel reviewing the projects studied. The second was the relative lack of standardized formal training in the conduct of reviews. It has been noted that almost everyone involved with reviews had education and experience within his or her area of expertise. However, the lack of a common base of training results in most of those doing reviews approaching them from the framework of past experiences. This does not lend itself to providing a consistent product due to the varied backgrounds of the individuals concerned. Whereas these areas by themselves do not present major problems, they can aggravate the overall lack of review quality consistency caused by the other procedural problems identified.

Review Time Available:

The major problem with reviews in this study was found to be the lack of available time. The time provided reviewers was found to be far short of the time needed to do reviews and other competing work requirements. Those tasked with the mission of technical and constructibility review were often the same individuals doing project design, quality assurance, construction inspection, modification processing, and other contract administration functions. It is concluded that reviews are not likely to receive the priority needed to be fully effective unless:

1. the review mission is conducted by individuals who have review as their first priority of effort or
2. the limitations imposed on review quality by reviewers having multiple responsibilities are recognized and planned for.

This could involve either:

1. a separate technical review team in Engineering Division and a separate constructibility review team within Construction Division or
2. one review team containing both design and construction experienced personnel

and

3. field representatives working with the review teams to make maximum use of the construction inspectors on-site expertise without placing the full responsibility for thorough constructibility review on their shoulders.

Since the functions of review and design are so closely intertwined, the review team (or teams) should be physically and organizationally located close to those doing project design. By separating reviews in

this manner, it would be possible to place a concentrated effort on reviews and thereby reduce modifications and cost growth.

Review Procedures:

A variety of procedural problems were discovered during this study. Although no one problem was found serious enough by itself to be significant, the combined effect of all is concluded to be major a detractor from review quality. Consequently, what is needed is an overall policy within the District that provides guidance on each issue. Such a policy should address the following items for both technical and constructibility reviews:

1. Guidance on what to review and how to review it. The use of checklists (such as the Navy's "Redicheck" system) could be used as a working tool to provide this guidance. In addition to assisting reviewers, a completed checklist would assist managers in coordinating reviews at different stages between different reviewers. The completed checklist would provide an indicator of which items have been reviewed and which have not (for whatever reason). Managers could use this information to determine where to concentrate future review effort.
2. Information flow procedures. This should include comments between reviewer, designer, and the customer. It should also include feedback from the designer to the reviewer as to the disposition of review comments. Finally, it should include methods insuring comments from previous reviews are made available to all subsequent reviewers.
3. Coordination of review comments. All review comments should be edited, evaluated, and consolidated prior to being turned over to the designer for action. This would preclude the designer having to decide between conflicting review comments. Techniques should be developed to insure appropriate review comments are incorporated into final design.
4. Site visits and use of destructive testing. Guidance should be provided on when site visits are needed, who conducts them, and what should be looked for at the site.

5. Formal review training procedures and standards.
6. Qualifications of review personnel.
7. Role of the customer in the review process. Guidance should be provided as to the type of comments expected from the customer (limited to scope definition and functional items) and the district's role in using service reviews.
8. The criteria by which reviewers are assigned to each project.

Such a policy, if properly enforced and combined with specialized review teams, could substantially improve review procedures and thereby reduce modifications and project cost growth.

Recommendations for Further Study:

The following is a summary of those topics recommended for additional study before final conclusions can be drawn:

1. The causes of user requested changes and the method by which functional reviews (or other actions) by the using service and the Corps can be used to preclude those causes.
2. Sources of design deficiencies and the design disciplines within which they are most likely to occur. This in turn could lead to a model for the conduct of reviews which focusses on the areas most likely to lead to modifications.
3. The impact of modifications, cost growth, and design/review procedures on District productivity, customer satisfaction, and the Corps professional reputation. Although often discussed, no studies were found which made a formal effort to analyze the effects of mods on these intangible elements of cost.
4. The cost effectiveness of reviews in relation to project cost growth. Recommend a study be conducted, using Finley's benefit cost analysis model (3), to quantify the actual benefit of technical and constructibility design review. It is further recommended that such an analysis

be conducted for reviews at each stage of design, with the intent of determining the break-even point between reduced cost growth and excessive, unproductive review.

5. The relationship between project type, project size, and design agency on change orders and cost growth. Although addressed in other studies, the findings to date are not in agreement and therefore not conclusive. Establishing a relationship between cost growth and these factors would help provide a focus for review effort.
6. The extent and impact non-essential administrative requirements, imposed on design elements within Engineering Division, detract from design and review quality. Data collected during this study indicated competing work requirements as a major reason reviews were not conducted to the level of thoroughness desired. However, the exact nature of those other tasks was not examined. Discussions with personnel within Engineering Division indicates many of them may be unnecessary. Identifying and eliminating unnecessary requirements could greatly assist in improving design and review effectiveness.
7. The impact of current funding rates and procedures on the quality of design and review. It is ironic that the Government places rather strict constraints on the money that can be spent on design and review and yet always has the money to pay later claims. Research in this area should concentrate on establishing realistic rates for design and review based on local conditions and project type, size, and scope.

Summary:

Excessive costs and cost growth are symptomatic of problems within the design and review process. The problems identified during this study are not new. Design deficiencies, unknown site conditions, and user requested changes have been identified in numerous studies and reports over the years as having substantially increased cost growth on military construction projects. It has been shown that these areas can be controlled by a thorough preconstruction design review process.

This process includes technical, constructibility, and using service reviews as well as improved customer involvement in the design and review process and improved review procedures. The chief mission of the Corps is good construction. Realizing that goal requires the dedication of resources long before construction actually begins. A commitment must be made by customers, Districts, and the Corps as a whole on this issue. Failing to devote adequate resources to preconstruction design and review activities is false economy. The connection between good reviews and low cost growth has been well established by this and other studies. One way or the other, reviews are going to be paid for. They can either be paid up front, with a corresponding decrease in cost growth, or they will be paid for during construction with lower District productivity, increased indirect cost, project delays, reduced customer satisfaction, and higher construction costs.

Endnotes - Chapter 7

1. USA-CERL, "Ways to Improve Construction Contract Modification Processing: USAFEA Korea Case Study", (CERL Technical Report P-85/11, May 1985).
2. Corps of Engineers South Atlantic Division, "Minutes of the Design Quality Forum", (Savannah District, 3 September 1985), page 2.
3. Lloyd S. Finley, "Examination of the Constructability [sic] Review in Government Contracting", (Master's thesis, Purdue University, School of Civil Engineering, 3 August 1984).

APPENDIX 1
OPERATIONAL DEFINITIONS

Operational Definitions

Bilateral Modification. A change order on which the Contracting Officer and the contractor have agreed to a price and/or time adjustment.

Change Order (Constructive). An act or failure to act by the Government which has the effect of requiring the contractor to accomplish work different from that required by the existing contract documents.

Change Order (Directed). A contract modification which requires the contractor to accomplish work different from that required by the existing contract documents where the changed work requirements fall under the general scope of the contract and within the physical limits of the construction site.

Changed Work. The contract requirements altered by a contract modification.

Claim. Any written demand by a contractor for money and/or time extensions arising under the contract terms, even if the amount of money or time is unstated.

Constructibility Review. Preconstruction design review conducted to insure the project can be built as designed. The purpose of this review is to identify potential construction conflicts within the design as well as between design and existing facilities.

Contract Change. Any variation from the terms or requirements of a contract. Commonly called "change" or "modification".

Contract Clause. Any general, special, or technical provision, or part thereof, of a contract.

Contract Completion Date. Date established by the contract for completion of all or of specified portions of the work.

Contracting Officer (CO). Any person (usually the District or Division Engineer, or his designated representative) authorized to enter into and administer contracts and to make determinations and findings with respect thereto.

Design Change ("No-fault" changes). A change for which redesign effort is required. A design change materially affects the approved requirements, the basis of design, the existing scope of the contract plans and specifications, or operating capability of the

facility. Examples of sources for design changes include changes to design criteria, building codes, safety codes, etc.

Design Deficiency. A design deficiency is defined as an error clearly due to faulty design or a deficiency due to the failure of the designer to properly take into account all visible aspects of site conditions. It is further defined as deficiencies due to the failure of the designer to proofread/coordinate plans and specifications. For the purpose of this study, the benefit of the doubt went to the designer. Any item of change included in a mod which does not meet the above criteria is listed under some classification other than design deficiency. Consequently, the quantity of items labeled as design deficiencies is probably conservative.

Differing (or Unknown) Site Conditions. Refers to (1) subsurface or latent physical conditions at the site differing materially from those indicated in the contract and (2) unknown physical conditions at the site, of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inhering in work of the character provided for in the contract.

Direct Costs. Cost of the materials, supplies, equipment, and prime contractor or sub-contractor work and labor that go into and can be clearly identified with a particular phase of construction.

Impact Costs. Impact costs are those costs related to the indirect effects of a change order. These effects are felt on portions of the project related to, but not directly involved with, the specific items being changed.

Indirect Costs. Indirect costs are those costs that cannot be attributed to a single item or unit of construction work. For this study, indirect costs are limited to administrative and wage costs incurred by the District to process modifications.

Items of Change. Those elements of the original contract being changed by the modification. For this study, all "line items of change" were considered equal, regardless of cost. For example, the removal of asbestos from Project #5 (total cost \$260,000) is one "item of change" as was the administrative correction of a paragraph of a specification even though the specification correction involves no cost to the government. Mods may include one or more of these change items. Like items within a mod are counted as only one "line item". For example, if five housing units involved in the same project each require identical changes to the electrical design, that change, even though repeated five times, is counted as one "line item of change".

Modification. A formal document that alters the contract specifications, delivery point, rate of delivery, contract period, price, quantity, or other contract provisions of an existing contract.

Resident Contracting Officer (RCO). The Government representative at the project site who is authorized to execute small dollar amount modifications under the Changes clause of the contract General Provisions. Under certain conditions he may be delegated greater monetary and/or authority under other clauses of the General Provisions.

Resident Engineer. The manager of the field office responsible to the district office for the immediate on-site administration of one or more construction contracts. This individual may or may not be the RCO for the contracts he administers.

Supplemental Agreement. A contract modification for work outside the scope of the contract.

Technical Review. Preconstruction design review conducted to insure appropriate codes, regulations, and design practices are adhered to. Its purpose is to identify errors in the technical aspects of design.

Unilateral Modification. A change order issued by the Contracting Officer in accordance with his determination of an equitable price and time adjustment, but which the contractor does not agree to and does not sign.

Using Service. The Government agency or other entity that will "own" and operate the facility being constructed.

Using Service Review. Preconstruction functional review conducted by the using service, usually under the supervision of DEH. At a minimum, it should be conducted at the concept review (10% design stage) and 65% completion stage of the design process to insure the design meets the requirements of those who are to use the finished product. The purpose of this review is to insure the project scope is understood by all and identify design/construction constraints imposed by the installation such as funding, time, joint occupancy, utilities, mobilization site security, etc.

APPENDIX 2
PROJECT SUMMARY SHEETS

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
29	Summary by Cost of Modification	154
30	Summary by Items of Change	156

TABLE 29

SUMMARY OF PROJECTS
By Cost of Modification

Data as of 24 Jan 1965

Type Project:	All Three Reviews:	Design Agency:	Size of Project:
MCA = 5	Yes = 21	IN-HOUSE = 5	Less than \$500,000 = 14
OMA = 15	No = 4	A/E = 20	\$500,000 - \$1,000,000 = 5
AFH = 5			\$1,000,000 - \$5,000,000 = 6

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ	PROJ
PROJ	TYPE	REVIEWS	MODS	USER	DESIGN	SITE	DESIGN	VALUE	OTHER	CONTR	COST	
NO.	PROJ	(No.)	DESIGN (TOT)	REQUEST	DEFICIENCY	COND	CHANGE	ENGR'NG		AMOUNT	GROWTH	
1	OMA	1	A/E	16	\$0	\$56,690	\$58,911	\$6,719	(\$374)	\$18,443	\$796,000 17.6%	
2	OMA	3	A/E	6	\$11,125	\$0	\$0	\$0	(\$658)	\$0	\$83,000 12.6%	
3	MCA	3	A/E	33	\$54,477	\$116,444	\$10,941	\$9,087	(\$3,263)	\$47,782	\$4,637,000 5.1%	
4	MMCA	3	A/E	18	\$44,931	\$19,701	\$19,141	\$2,338	\$0	\$0	\$893,600 9.6% *	
5	MCA	3	A/E	39	\$69,081	\$52,778	\$287,645	\$2,400	\$0	\$0	\$4,666,590 8.8% **	
6	OMA	3	I-H (I)	6	\$0	\$390	\$6,475	\$0	\$0	\$17,250	\$224,567 10.7%	
7	OMA	3	A/E	6	\$0	\$1,923	\$565	\$324	\$0	\$0	\$340,000 0.8%	
8	OMA	3	A/E	3	\$6,606	\$0	(\$7,736)	\$151	\$0	\$150	\$157,500 -0.5%	
9	OMA	3	I-H (I)	2	\$0	\$0	\$2,924	\$0	\$0	\$0	\$1,006,260 0.3%	
10	OMA	3	A/E	1	\$0	\$5,814	\$0	\$0	\$0	\$0	\$79,191 7.3%	
11	OMA	3	A/E	7	\$0	\$52,841	\$11,356	(\$13,070)	\$0	\$4,505	\$488,970 11.4%	
12	OMA	3	I-H (D)	1	\$0	\$0	\$0	(\$100)	\$0	\$0	\$71,432 -0.1%	
13	OMA	3	A/E	8	\$5,331	\$8,827	\$0	\$6,086	\$0	\$7,295	\$209,603 13.1%	
14	AFH	3	A/E	25	\$16,199	\$24,110	\$57,540	\$4,477	\$0	\$59,096	\$860,518 18.8%	
15	OMA	2	A/E	16	\$189,818	\$3,178	\$187,659	\$43,380	\$0	\$53,373	\$536,300 89.0% **	
16	AFH	0	A/E	5	\$9,765	\$8,469	\$3,778	\$3,132	\$0	\$0	\$207,500 12.1%	
17	AFH	2	A/E	5	\$0	\$44,595	\$0	\$0	\$0	\$7,725	\$411,373 12.7%	
18	MCA	3	I-H (D)	12	\$14,114	\$56,975	\$0	\$7,886	\$0	\$7,000	\$3,000,000 2.9%	
19	MCA	3	A/E	28	\$4,608	\$47,959	\$97,713	\$11,022	(\$2,516)	\$0	\$4,075,100 3.9% *	
20	OMA	3	A/E	10	\$10,459	\$2,492	\$6,416	\$0	\$0	\$0	\$267,000 7.3%	
21	OMA	3	I-H (I)	6	\$24,486	\$276	\$0	\$0	\$0	\$1,897	\$605,443 4.4%	
22	AFH	3	A/E	6	\$20,123	(\$7,500)	\$0	\$319,250	\$0	\$0	\$1,247,433 26.6% * **	
23	AFH	3	A/E	6	\$9,323	\$0	\$0	\$43,775	\$0	\$0	\$505,742 10.5%	
24	OMA	3	A/E	2	\$1,959	\$0	\$0	\$0	\$0	\$0	\$173,000 1.1%	
25	OMA	3	A/E	1	\$0	\$0	\$0	\$0	\$0	\$2,798	\$254,500 1.1%	
TOTALS			268	\$492,405	\$495,892	\$743,328	\$446,857	\$6,811	\$227,314	\$25,797,622	9.4%	
PERCENTAGES				20.4%	20.6%	30.8%	18.5%	0.3%	9.4%			

(CONTINUED ON NEXT PAGE)

TABLE 29

Project Summary (By Cost - Continued)

NOTES:

1. Project #5 terminated. Mods shown do not include those initiated because of termination.
2. Project #11 award amount adjusted for deleted work.
3. Project #14 award amount adjusted for deleted work.
4. Project #17 award amount adjusted to reflect user requested credit of \$33,804.
Credit resulted from termination of work. Bid amount adjusted by subtracting value of work not completed from original contract value.
5. Project #21 award amount adjusted for deleted work.
6. Project #22 award amount adjusted for deleted work.
7. Project #23 award amount increased by amount of supplemental agreement.
8. Sums for value engineering mods shown as absolute value of dollar amount.
9. Asterisk (*) indicates projects not yet complete:
Project # 4 at 96% as of 24 Jan 86.
Project #19 at 99% as of 24 Jan 86.
Project #22 at 81% as of 24 Jan 86.
10. I-H (I) indicates in-house design done by the installation.
I-H (D) indicates in-house design done by the supporting District office.
11. Double asterisk (**) indicates projects that were further adjusted as follows:

There are two individual expense items which have a disproportionate impact on the results shown above. These are the asbestos removal from Project #5 (\$260,194) and criteria change in Project #22 (\$319,250).
If these two items are removed, the resulting sums and percentages are as follows:

	USER	DESIGN	SITE	DESIGN	VALUE	
	REQUEST	DEFICIENCY	COND	CHANGE	ENGR'NG	OTHER
TOTALS	\$492,405	\$495,892	\$483,134	\$127,607	\$6,811	\$227,314
PERCENTAGES	26.9%	27.1%	26.4%	7.0%	0.4%	12.4%

The problems encountered in Project #15 (total mods \$387,254) also have a disproportionate effect on the results. If this project is deleted, the results are:

	USER	DESIGN	SITE	DESIGN	VALUE	
	REQUEST	DEFICIENCY	COND	CHANGE	ENGR'NG	OTHER
TOTALS	\$302,587	\$492,714	\$295,475	\$84,227	\$6,811	\$173,941
PERCENTAGES	22.3%	36.3%	21.8%	6.2%	0.5%	12.8%

Two types of expenses make up more than 50% of the amount shown under "others". These are problems with site access (\$43,329) and slowness in reviewing shop drawings (\$51,000).

TABLE 30

SUMMARY OF PROJECTS
By Item of Change

Data as of 24 Jan 1986

Type Project:	All Three Reviews:	Design Agency:	Size of Project:
MCA = 5	Yes = 21	IN-HOUSE = 5	Less than \$500,000 = 14
OMA = 15	No = 4	A/E = 20	\$500,000 - \$1,000,000 = 5
AFH = 5			\$1,000,000 - \$5,000,000 = 6

REASON FOR MODIFICATION (By Item of Change)												ADJ	PROJ
NO.	TYPE	REVIEWS	MODS	USER	DESIGN	SITE	DESIGN	VALUE	OTHER	CONTR	COST		
	PROJ	(No.)	DESIGN (TOT)	REQUEST	DEFICIENCY	COND	CHANGE	ENGR'NG		AMOUNT	GROWTH		
1	OMA	1	A/E 16	0	30	7	2	1	3	\$796,000	17.6%		
2	OMA	3	A/E 6	3	1	0	0	1	1	\$83,000	12.6%		
3	MCA	3	A/E 33	11	69	1	9	2	8	\$4,637,000	5.1%		
4	MMCA	3	A/E 18	6	13	5	2	0	3	\$893,600	9.6% *		
5	MCA	3	A/E 39	59	24	8	3	0	3	\$4,666,590	8.8% **		
6	OMA	3	I-H (I) 6	0	1	4	0	0	3	\$224,567	10.7%		
7	OMA	3	A/E 6	0	2	1	2	0	1	\$340,000	0.8%		
8	OMA	3	A/E 3	3	3	2	1	0	4	\$157,500	-0.5%		
9	OMA	3	I-H (I) 2	0	0	1	0	0	2	\$1,006,260	0.3%		
10	OMA	3	A/E 1	0	1	0	0	0	0	\$79,191	7.3%		
11	OMA	3	A/E 7	0	13	4	6	0	3	\$488,970	11.4%		
12	OMA	3	I-H (D) 1	0	0	0	1	0	0	\$71,432	-0.1%		
13	OMA	3	A/E 8	4	2	0	4	0	1	\$209,603	13.1%		
14	AFH	3	A/E 25	27	16	111	12	0	8	\$860,518	18.8%		
15	OMA	2	A/E 16	24	6	34	4	0	4	\$536,300	89.0% **		
16	AFH	0	A/E 5	5	6	16	2	0	3	\$207,500	12.1%		
17	AFH	2	A/E 5	0	12	0	0	0	2	\$411,373	12.7%		
18	MCA	3	I-H (D) 12	3	14	0	3	0	2	\$3,000,000	2.9%		
19	MCA	3	A/E 28	2	22	31	2	3	4	\$4,075,100	3.9% *		
20	OMA	3	A/E 10	6	3	3	0	0	1	\$267,000	7.3%		
21	OMA	3	I-H (I) 6	9	1	0	2	0	4	\$695,443	4.4%		
22	AFH	3	A/E 6	6	1	0	1	0	1	\$1,247,433	26.6% * **		
23	AFH	3	A/E 6	4	0	0	7	0	0	\$505,742	10.5%		
24	OMA	3	A/E 2	5	0	0	1	0	0	\$173,000	1.1%		
25	OMA	3	A/E 1	0	0	0	0	0	1	\$254,500	1.1%		
TOTALS 268				177	240	228	64	7	62	\$25,797,622	9.4%		
PERCENTAGES				22.8%	30.8%	29.3%	8.2%	0.9%	8.0%				

(CONTINUED ON NEXT PAGE)

TOTAL ITEMS OF CHANGE: 778

TABLE 30

Project Summary (By Item of Change - Continued)

NOTES:

1. Project #5 terminated. Mods shown do not include those initiated because of termination.
2. Asterisk (*) indicates projects not yet complete:
 Project # 4 at 96% as of 24 Jan 86.
 Project #19 at 99% as of 24 Jan 86.
 Project #22 at 81% as of 24 Jan 86.
3. I-H (I) indicates in-house design done by the installation.
 I-H (D) indicates in-house design done by the supporting District office.
4. Double asterisk (**) indicates projects that were further adjusted as follows:

There are two individual expense items which have a disproportionate impact on the results shown above. These are the asbestos removal from Project #5 (\$260,194) and criteria change in Project #22 (\$319,250). To maintain consistency, these two items were removed from this analysis as they were for the "cost" analysis:

	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER
TOTALS	177	240	227	63	7	62
PERCENTAGES	22.8%	30.9%	29.3%	8.1%	0.9%	8.0%

The problems encountered in Project #15 (total mods \$387,254) also have a disproportionate effect on the cost results. If this project is deleted, the results are:

	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER
TOTALS	153	234	193	59	7	58
PERCENTAGES	21.7%	33.2%	27.4%	8.4%	1.0%	8.2%

Two types of expenses make up more than 50% of the amount shown under "others". These are problems with site access (\$43,329) and slowness in reviewing shop drawings (\$51,600).

APPENDIX 3
CAUSES OF DESIGN DEFICIENCIES

TABLE	TITLE	PAGE
31	Summary by Cost	159
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TABLE 31

REASONS FOR DESIGN DEFICIENCIES
By Cost of Modification

Data as of 24 Jan 1985

DISCIPLINE IN WHICH ERROR OCCURRED (By Cost)												DSGN DEF	
												AMOUNT	AS PCT OF
PROJ	TYPE	REVIEWS	MODS								ADMIN	DUE TO	PROJ MOD
NO.	PROJ	(No.)	DESIGN (TOT)	CIVIL	MECH	ELEC	STRUCT	ARCH	CHANGE	DSGN ERR	COST		
1	OMA	1	A/E	16	\$0	\$13,532	\$11,325	\$0	\$31,833	\$0	\$56,690	40.4%	
2	OMA	3	A/E	6	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
3	MCA	3	A/E	33	\$0	\$9,995	\$1,173	\$16,666	\$88,610	\$0	\$116,444	49.5%	
4	MMCA	3	A/E	18	\$0	\$4,067	\$0	\$0	\$15,634	\$0	\$19,701	22.9%	
5	MCA	3	A/E	39	\$5,110	\$24,035	\$0	\$0	\$23,633	\$0	\$52,778	12.8%	
6	OMA	3	I-H(I)	6	\$0	\$0	\$390	\$0	\$0	\$0	\$390	1.6%	
7	OMA	3	A/E	6	\$0	\$1,923	\$0	\$0	\$0	\$0	\$1,923	68.4%	
8	OMA	3	A/E	3	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
9	OMA	3	I-H(I)	2	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
10	OMA	3	A/E	1	\$0	\$5,814	\$0	\$0	\$0	\$0	\$5,814	100.0%	
11	OMA	3	A/E	7	\$0	\$52,841	\$0	\$0	\$0	\$0	\$52,841	47.9%	
12	OMA	3	I-H(D)	1	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
13	OMA	3	A/E	8	\$0	\$0	\$787	\$0	\$8,040	\$0	\$8,827	32.1%	
14	AFH	3	A/E	25	\$0	\$617	\$110	\$0	\$23,383	\$0	\$24,110	14.9%	
15	OMA	2	A/E	16	\$0	\$442	\$2,336	\$0	\$400	\$0	\$3,178	0.7%	
16	AFH	0	A/E	5	\$7,209	\$0	\$0	\$0	\$1,260	\$0	\$8,469	33.7%	
17	AFH	2	A/E	5	\$13,329	\$0	\$0	\$0	\$31,266	\$0	\$44,595	85.2%	
18	MCA	3	I-H(D)	12	\$0	\$8,500	\$0	\$12,787	\$35,688	\$0	\$56,975	66.3%	
19	MCA	3	A/E	28	\$9,424	\$2,892	\$13,010	\$0	\$22,633	\$0	\$47,959	30.2%	
20	OMA	3	A/E	10	\$0	\$0	\$0	\$0	\$2,492	\$0	\$2,492	12.9%	
21	OMA	3	I-H(I)	6	\$0	\$0	\$0	\$0	\$206	\$0	\$206	0.8%	
22	AFH	3	A/E	6	\$0	(\$7,500)	\$0	\$0	\$0	\$0	(\$7,500)	-2.3%	
23	AFH	3	A/E	6	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
24	OMA	3	A/E	2	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
25	OMA	3	A/E	1	\$0	\$0	\$0	\$0	\$0	\$0	\$0	0.0%	
TOTALS				268	\$35,072	\$117,158	\$29,131	\$29,453	\$285,078	\$0	\$495,892		
PERCENTAGES					7.1%	23.6%	5.9%	5.9%	57.5%	0.0%			

TABLE 32

REASONS FOR DESIGN DEFICIENCIES
By Items of Change

Data as of 24 Jan 1985

DISCIPLINE IN WHICH ERROR OCCURRED											DSGN ERR	
(By Items of Change)											AS PCT OF	
PROJ TYPE	REVIEWS	DESIGN	MODS	ADMIN							DUE TO	PROJ MOD
NO.	PROJ	(No.)	AUTH	(TOT)	CIVIL	MECH	ELEC	STRUCT	ARCH	CHANGES	DSGN ERR	COST
1	OMA	1	A/E	16	0	9	16	0	5	0	\$56,690	40.4%
2	OMA	3	A/E	6	0	1	0	0	0	0	\$0	0.0%
3	MCA	3	A/E	33	0	8	1	18	37	5	\$116,444	49.5%
4	MMCA	3	A/E	18	0	2	0	1	9	1	\$19,701	22.9%
5	MCA	3	A/E	39	1	13	0	0	10	0	\$52,778	12.8%
6	OMA	3	I-H(I)	6	0	0	1	0	0	0	\$390	1.6%
7	OMA	3	A/E	6	0	1	0	0	1	0	\$1,923	68.4%
8	OMA	3	A/E	3	0	0	0	0	0	3	\$0	0.0%
9	OMA	3	I-H(I)	2	0	0	0	0	0	0	\$0	0.0%
10	OMA	3	A/E	1	0	1	0	0	0	0	\$5,814	100.0%
11	OMA	3	A/E	7	0	13	0	0	0	0	\$52,841	47.9%
12	OMA	3	I-H(D)	1	0	0	0	0	0	0	\$0	0.0%
13	OMA	3	A/E	8	0	0	1	0	1	0	\$8,827	32.1%
14	AFH	3	A/E	25	0	4	5	0	6	1	\$24,110	14.9%
15	OMA	2	A/E	16	0	1	4	0	1	0	\$3,178	9.7%
16	AFH	0	A/E	5	5	0	0	0	1	0	\$8,469	33.7%
17	AFH	2	A/E	5	4	0	0	0	8	0	\$44,595	85.2%
18	MCA	3	I-H(D)	12	0	3	0	6	5	0	\$56,975	66.3%
19	MCA	3	A/E	28	2	4	2	0	12	2	\$47,959	30.2%
20	OMA	3	A/E	10	0	0	0	0	3	0	\$2,492	12.9%
21	OMA	3	I-H(I)	6	0	0	0	0	1	0	\$266	0.8%
22	AFH	3	A/E	6	0	1	0	0	0	0	(\$7,500)	-2.3%
23	AFH	3	A/E	6	0	0	0	0	0	0	\$0	0.0%
24	OMA	3	A/E	2	0	0	0	0	0	0	\$0	0.0%
25	OMA	3	A/E	1	0	0	0	0	0	0	\$0	0.0%
TOTALS				268	12	61	30	25	100	12	\$495,892	
PERCENTAGES					5.0%	25.4%	12.5%	10.4%	41.7%	5.0%		

TOTAL DESIGN DEF: 240

APPENDIX 4

MODIFICATION COST CORRELATION TABLES

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TABLE 33

CORRELATION BY PRECONSTRUCTION REVIEWS
(Note Table Adjusted for High-Cost Mods to Projects #5 and 22)

Projects Not Receiving all 3 Reviews:

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ PROJ	
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER		CONTR AMOUNT	COST GROWTH
1	OMA	1	A/E 16	\$0	\$56,690	\$58,911	\$6,719	(\$374)	\$18,443		\$796,000	17.6%
15	OMA	2	A/E 16	\$189,818	\$3,178	\$187,659	\$43,380	\$0	\$53,373		\$536,300	89.0%
16	AFH	0	A/E 5	\$9,765	\$8,469	\$3,778	\$3,132	\$0	\$0		\$207,500	12.1%
17	AFH	2	A/E 5	\$0	\$44,595	\$0	\$0	\$0	\$7,725		\$411,373	12.7%
											\$1,951,173	35.6%
If Project #15 is deleted:											\$1,414,873	15.4%

Projects Receiving all 3 Reviews:

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ PROJ	
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER		CONTR AMOUNT	COST GROWTH
2	OMA	3	A/E 6	\$11,125	\$0	\$0	\$0	(\$658)	\$0		\$83,000	12.6%
3	MCA	3	A/E 33	\$54,477	\$116,444	\$10,941	\$9,087	(\$3,263)	\$47,782		\$4,637,000	5.1%
4	MMCA	3	A/E 18	\$44,931	\$19,701	\$19,141	\$2,338	\$0	\$0		\$893,600	9.6%
5	MCA	3	A/E 39	\$69,081	\$52,778	\$27,451	\$2,400	\$0	\$0		\$4,666,590	3.3%
6	OMA	3	I-H (I) 6	\$0	\$390	\$6,475	\$0	\$0	\$17,250		\$224,567	10.7%
7	OMA	3	A/E 5	\$0	\$1,923	\$565	\$324	\$0	\$0		\$340,000	0.8%
8	OMA	3	A/E 3	\$6,606	\$0	(\$7,736)	\$151	\$0	\$150		\$157,500	-0.5%
9	OMA	3	I-H (I) 2	\$0	\$0	\$2,924	\$0	\$0	\$0		\$1,006,260	0.3%
10	OMA	3	A/E 1	\$0	\$5,814	\$0	\$0	\$0	\$0		\$79,191	7.3%
11	OMA	3	A/E 7	\$0	\$52,841	\$11,356	(\$13,070)	\$0	\$4,505		\$488,970	11.4%
12	OMA	3	I-H (D) 1	\$0	\$0	\$0	(\$100)	\$0	\$0		\$71,432	-0.1%
13	OMA	3	A/E 8	\$5,331	\$8,827	\$0	\$6,086	\$0	\$7,295		\$209,605	13.1%
14	AFH	3	A/E 25	\$16,199	\$24,110	\$57,540	\$4,477	\$0	\$59,096		\$860,518	18.8%
18	MCA	3	I-H (D) 12	\$14,114	\$56,975	\$0	\$7,886	\$0	\$7,000		\$3,000,000	2.9%
19	MCA	3	A/E 28	\$4,608	\$47,959	\$97,713	\$11,022	(\$2,516)	\$0		\$4,075,100	3.9%
20	OMA	3	A/E 10	\$10,459	\$2,492	\$6,416	\$0	\$0	\$0		\$267,000	7.3%
21	OMA	3	I-H (I) 6	\$24,486	\$206	\$0	\$0	\$0	\$1,897		\$605,443	4.4%
22	AFH	3	A/E 6	\$20,123	(\$7,500)	\$0	\$0	\$0	\$0		\$1,247,433	1.0%
23	AFH	3	A/E 6	\$9,323	\$0	\$0	\$43,775	\$0	\$0		\$505,742	10.5%
24	OMA	3	A/E 2	\$1,959	\$0	\$0	\$0	\$0	\$0		\$173,000	1.1%
25	OMA	3	A/E 1	\$0	\$0	\$0	\$0	\$0	\$2,798		\$254,500	1.1%
											\$23,846,449	4.7%

TABLE 34

CORRELATION BY PROJECT TYPE
(Note Table Adjusted for High-Cost Mods to Projects #5 and 22)

AFH Projects:

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ CONTR AMOUNT	PROJ COST GROWTH
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER			
14	AFH	3	A/E	25	\$16,199	\$24,110	\$57,540	\$4,477	\$0	\$59,096	\$860,518	18.8%
16	AFH	0	A/E	5	\$9,765	\$8,469	\$3,778	\$3,132	\$0	\$0	\$207,500	12.1%
17	AFH	2	A/E	5	\$0	\$44,595	\$0	\$0	\$0	\$7,725	\$411,373	12.7%
22	AFH	3	A/E	6	\$20,123	(\$7,500)	\$0	\$0	\$0	\$0	\$1,247,433	1.0%
23	AFH	3	A/E	6	\$9,323	\$0	\$0	\$43,775	\$0	\$0	\$505,742	10.5%
											\$3,232,566	9.4%

MCA Projects:

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ CONTR AMOUNT	PROJ COST GROWTH
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER			
3	MCA	3	A/E	33	\$54,477	\$116,444	\$10,941	\$9,087	(\$3,263)	\$47,782	\$4,637,000	5.1%
4	MMCA	3	A/E	18	\$44,931	\$19,701	\$19,141	\$2,338	\$0	\$0	\$893,600	9.6%
5	MCA	3	A/E	39	\$69,081	\$52,778	\$27,451	\$2,400	\$0	\$0	\$4,666,590	3.3%
18	MCA	3	I-H (D)	12	\$14,114	\$56,975	\$0	\$7,886	\$0	\$7,000	\$3,000,000	2.9%
19	MCA	3	A/E	28	\$4,608	\$47,959	\$97,713	\$11,022	(\$2,516)	\$0	\$4,075,100	3.9%
											\$17,272,290	4.2%

OMA Projects:

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ CONTR AMOUNT	PROJ COST GROWTH
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER			
1	OMA	1	A/E	16	\$0	\$56,690	\$58,911	\$6,719	(\$374)	\$18,443	\$796,000	17.6%
2	OMA	3	A/E	6	\$11,125	\$0	\$0	\$0	(\$658)	\$0	\$83,000	12.6%
6	OMA	3	I-H (I)	6	\$0	\$390	\$6,475	\$0	\$0	\$17,250	\$224,567	10.7%
7	OMA	3	A/E	6	\$0	\$1,923	\$565	\$324	\$0	\$0	\$340,000	0.8%
8	OMA	3	A/E	3	\$6,606	\$0	(\$7,736)	\$151	\$0	\$150	\$157,500	-0.5%
9	OMA	3	I-H (I)	2	\$0	\$0	\$2,924	\$0	\$0	\$0	\$1,006,260	0.3%
10	OMA	3	A/E	1	\$0	\$5,814	\$0	\$0	\$0	\$0	\$79,191	7.3%
11	OMA	3	A/E	7	\$0	\$52,841	\$11,356	(\$13,070)	\$0	\$4,505	\$488,970	11.4%
12	OMA	3	I-H (D)	1	\$0	\$0	\$0	(\$100)	\$0	\$0	\$71,432	-0.1%
13	OMA	3	A/E	8	\$5,331	\$8,827	\$0	\$6,086	\$0	\$7,295	\$209,603	13.1%
15	OMA	2	A/E	16	\$189,818	\$3,178	\$187,659	\$43,380	\$0	\$53,373	\$536,300	89.0%
20	OMA	3	A/E	10	\$10,459	\$2,492	\$6,416	\$0	\$0	\$0	\$267,000	7.3%
21	OMA	3	I-H (I)	6	\$24,486	\$206	\$0	\$0	\$0	\$1,897	\$605,443	4.4%
24	OMA	3	A/E	2	\$1,959	\$0	\$0	\$0	\$0	\$0	\$173,000	1.1%
25	OMA	3	A/E	1	\$0	\$0	\$0	\$0	\$0	\$2,798	\$254,500	1.1%
											\$5,292,766	15.1%
If Project #15 is deleted:											\$4,756,466	6.7%

TABLE 35

CORRELATION BY PROJECT SIZE
(Note Table Adjusted for High-Cost Mods on Projects #5 and 22)

Projects With Adjusted Contract Amounts of Less Than \$500,000

REASON FOR MODIFICATION (By Cost per Item of Change)											ADJ CONTR AMOUNT	PROJ COST GROWTH
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS : DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER			
2	OMA	3	A/E 6	\$11,125	\$0	\$0	\$0	(\$658)	\$0		\$83,000	12.6%
6	OMA	3	I-H (I) 6	\$0	\$390	\$6,475	\$0	\$0	\$17,250		\$224,567	10.7%
7	OMA	3	A/E 6	\$0	\$1,923	\$565	\$324	\$0	\$0		\$340,000	0.8%
8	OMA	3	A/E 3	\$6,606	\$0	(\$7,736)	\$151	\$0	\$150		\$157,500	-0.5%
10	OMA	3	A/E 1	\$0	\$5,814	\$0	\$0	\$0	\$0		\$79,191	7.3%
11	OMA	3	A/E 7	\$0	\$52,841	\$11,356	(\$13,070)	\$0	\$4,505		\$488,970	11.4%
12	OMA	3	I-H (D) 1	\$0	\$0	\$0	(\$100)	\$0	\$0		\$71,432	-0.1%
13	OMA	3	A/E 8	\$5,331	\$8,827	\$0	\$6,086	\$0	\$7,295		\$209,603	13.1%
16	AFH	0	A/E 5	\$9,765	\$8,469	\$3,778	\$3,132	\$0	\$0		\$207,500	12.1%
17	AFH	2	A/E 5	\$0	\$44,595	\$0	\$0	\$0	\$7,725		\$411,373	12.7%
20	OMA	3	A/E 10	\$10,459	\$2,492	\$6,416	\$0	\$0	\$0		\$267,000	7.3%
24	OMA	3	A/E 2	\$1,959	\$0	\$0	\$0	\$0	\$0		\$173,000	1.1%
25	OMA	3	A/E 1	\$0	\$0	\$0	\$0	\$0	\$2,798		\$254,500	1.1%
											\$2,967,636	7.7%

Projects With Adjusted Contract Amounts Between \$500,000 and \$1,000,000.

PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS : DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER		ADJ CONTR AMOUNT	PROJ COST GROWTH
1	OMA	1	A/E 16	\$0	\$56,690	\$58,911	\$6,719	(\$374)	\$18,443		\$796,000	17.6%
4	MCA	3	A/E 18	\$44,931	\$19,701	\$19,141	\$2,338	\$0	\$0		\$893,600	9.6%
14	AFH	3	A/E 25	\$16,199	\$24,110	\$57,540	\$4,477	\$0	\$59,096		\$860,518	18.8%
15	OMA	2	A/E 16	\$189,818	\$3,178	\$187,659	\$43,380	\$0	\$53,373		\$536,300	89.0%
21	OMA	3	I-H (I) 6	\$24,486	\$206	\$0	\$0	\$0	\$1,897		\$605,443	4.4%
23	AFH	3	A/E 6	\$9,323	\$0	\$0	\$43,775	\$0	\$0		\$505,742	10.5%
											\$4,197,603	22.5%
											\$3,661,303	12.8%

If Project #15 is deleted:

Projects With Adjusted Contract Amounts Over \$1,000,000.

PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS : DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER		ADJ CONTR AMOUNT	PROJ COST GROWTH
3	MCA	3	A/E 33	\$54,477	\$116,444	\$10,941	\$9,087	(\$3,263)	\$47,782		\$4,637,000	5.1%
5	MCA	3	A/E 39	\$69,081	\$52,778	\$27,451	\$2,400	\$0	\$0		\$4,666,590	3.3%
9	OMA	3	I-H (I) 2	\$0	\$0	\$2,924	\$0	\$0	\$0		\$1,006,260	0.3%
18	MCA	3	I-H (D) 12	\$14,114	\$56,975	\$0	\$7,886	\$0	\$7,000		\$3,000,000	2.9%
19	MCA	3	A/E 28	\$4,608	\$47,959	\$97,713	\$11,022	(\$2,516)	\$0		\$4,075,100	3.9%
22	AFH	3	A/E 6	\$20,123	(\$7,500)	\$0	\$0	\$0	\$0		\$1,247,433	1.0%
											\$18,632,383	3.5%

TABLE 36

CORRELATION BY DESIGN (IN-HOUSE VS. CONTRACTED A/E)
(Note Table Adjusted for High-Cost Mods on Projects #5 and 22)

A/E Designed Projects:

REASON FOR MODIFICATION (By Cost per Item of Change)											
PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER	ADJ CONTR AMOUNT	PROJ COST GROWTH
1	OMA	1	A/E	16	\$0	\$56,690	\$58,911	\$6,719	(\$374)	\$18,443	\$796,000 17.6%
2	OMA	3	A/E	6	\$11,125	\$0	\$0	\$0	(\$658)	\$0	\$83,000 12.6%
3	MCA	3	A/E	33	\$54,477	\$116,444	\$10,941	\$9,087	(\$3,263)	\$47,782	\$4,637,000 5.1%
4	MMCA	3	A/E	18	\$44,931	\$19,701	\$19,141	\$2,338	\$0	\$0	\$893,600 9.6%
5	MCA	3	A/E	39	\$69,081	\$52,778	\$27,451	\$2,400	\$0	\$0	\$4,666,590 3.3%
7	OMA	3	A/E	6	\$0	\$1,923	\$565	\$324	\$0	\$0	\$340,000 0.8%
8	OMA	3	A/E	3	\$6,606	\$0	(\$7,736)	\$151	\$0	\$150	\$157,500 -0.5%
10	OMA	3	A/E	1	\$0	\$5,814	\$0	\$0	\$0	\$0	\$79,191 7.3%
11	OMA	3	A/E	7	\$0	\$52,841	\$11,356	(\$13,070)	\$0	\$4,505	\$488,970 11.4%
13	OMA	3	A/E	8	\$5,331	\$8,827	\$0	\$6,086	\$0	\$7,295	\$209,603 13.1%
14	AFH	3	A/E	25	\$16,199	\$24,110	\$57,540	\$4,477	\$0	\$59,096	\$860,518 18.8%
15	OMA	2	A/E	16	\$189,818	\$3,178	\$187,659	\$43,380	\$0	\$53,373	\$536,300 89.0%
16	AFH	0	A/E	5	\$9,765	\$8,469	\$3,778	\$3,132	\$0	\$0	\$207,500 12.1%
17	AFH	2	A/E	5	\$0	\$44,595	\$0	\$0	\$0	\$7,725	\$411,373 12.7%
19	MCA	3	A/E	28	\$4,608	\$47,959	\$97,713	\$11,022	(\$2,516)	\$0	\$4,075,100 3.9%
20	OMA	3	A/E	10	\$10,459	\$2,492	\$6,416	\$0	\$0	\$0	\$267,000 7.3%
22	AFH	3	A/E	6	\$20,123	(\$7,500)	\$0	\$0	\$0	\$0	\$1,247,433 1.0%
23	AFH	3	A/E	6	\$9,323	\$0	\$0	\$43,775	\$0	\$0	\$505,742 10.5%
24	OMA	3	A/E	2	\$1,959	\$0	\$0	\$0	\$0	\$0	\$173,000 1.1%
25	OMA	3	A/E	1	\$0	\$0	\$0	\$0	\$0	\$2,798	\$254,500 1.1%
											=====
											\$20,889,920 8.0%
If Project #15 is deleted:											\$20,353,620 5.9%

Designed by In-House, Government Engineers:

PROJ NO.	TYPE PROJ	REVIEWS (No.)	MODS DESIGN (TOT)	USER REQUEST	DESIGN DEFICIENCY	SITE COND	DESIGN CHANGE	VALUE ENGR'NG	OTHER	ADJ CONTR AMOUNT	PROJ COST GROWTH
6	OMA	3	I-H (I)	6	\$0	\$390	\$6,475	\$0	\$0	\$17,250	\$224,567 10.7%
9	OMA	3	I-H (I)	2	\$0	\$0	\$2,924	\$0	\$0	\$0	\$1,006,260 0.3%
12	OMA	3	I-H (D)	1	\$0	\$0	\$0	(\$100)	\$0	\$0	\$71,432 -0.1%
19	MCA	3	I-H (D)	12	\$14,114	\$56,975	\$0	\$7,886	\$0	\$7,000	\$3,000,000 2.9%
21	OMA	3	I-H (I)	6	\$24,486	\$206	\$0	\$0	\$0	\$1,897	\$605,443 4.4%
											=====
											\$4,907,702 2.8%

NOTE: I-H (I) indicates design by installation.
I-H (D) indicates design by supporting Corps District.

APPENDIX 5

INDIRECT COSTS FOR ENGINEERING, DESIGN, AND OVERHEAD
BY PROJECT

TABLE 37

MOD COST COMPARISON
 District Costs for Engineering, Design, and Overhead

PROJ NO.	DIRECT MOD COST	TOTAL ITEMS OF CHNG	MODS (TOT)	DIRECT PROJ COST GROWTH	COST OF MODIFICATION ENGR, DESIGN, AND OVERHEAD			ADMIN COST		ADJUSTED CONTRACT AMOUNT
					E&D	OVERHD	TOTAL	(E&D, OVRHD)	PER MOD OF CHNG	
1	\$140,390	43	16	17.6%	\$4,102	\$50	\$4,152	\$260	\$97	\$798,000
2	\$10,467	6	6	12.6%	\$286	\$41	\$327	\$54	\$54	\$83,000
3	\$235,468	100	33	5.1%	\$19,983	\$2,956	\$22,939	\$695	\$229	\$4,637,000
4	\$86,111	29	18	9.6%	\$4,925	\$676	\$5,601	\$311	\$193	\$893,600
5	\$411,844	97	39	8.8%	\$24,330	\$2,424	\$26,754	\$686	\$276	\$4,666,590
6	\$24,115	8	6	10.7%	\$968	\$156	\$1,124	\$187	\$140	\$224,567
7	\$2,811	6	6	0.8%	\$1,580	\$236	\$1,816	\$303	\$303	\$340,000
8	(\$829)	13	3	-0.5%	\$713	\$108	\$821	\$274	\$63	\$157,500
9	\$2,924	3	2	0.3%	\$670	\$98	\$768	\$384	\$256	\$1,006,260
10	\$5,814	1	1	7.3%	\$315	\$48	\$363	\$363	\$363	\$79,191
11	\$55,632	26	7	11.4%	\$2,209	\$333	\$2,543	\$363	\$98	\$488,970
12	(\$100)	1	1	-0.1%	\$437	\$71	\$509	\$509	\$509	\$71,432
13	\$27,539	11	8	13.1%	\$844	\$128	\$972	\$121	\$88	\$209,603
14	\$161,420	179	25	18.7%	\$3,509	\$503	\$4,012	\$160	\$22	\$860,518
15	\$477,408	72	16	89.0%	\$2,363	\$370	\$2,733	\$171	\$38	\$536,300
16	\$25,145	31	5	12.1%	\$893	\$131	\$1,023	\$205	\$33	\$207,500
17	\$52,320	14	5	11.8%	\$2,156	\$269	\$2,425	\$485	\$173	\$411,373
18	\$85,975	22	12	2.9%	\$13,189	\$2,118	\$15,308	\$1,276	\$696	\$3,000,000
19	\$158,786	64	28	3.9%	\$17,252	\$2,806	\$20,058	\$716	\$313	\$4,075,100
20	\$19,367	13	10	7.3%	\$1,508	\$245	\$1,753	\$0	\$0	\$267,000
21	\$26,589	16	6	4.4%	\$2,888	\$482	\$3,370	\$562	\$211	\$605,443
22	\$331,873	9	6	26.6%	\$5,035	\$784	\$5,819	\$0	\$647	\$1,247,433
23	\$53,098	11	6	10.5%	\$1,296	\$202	\$1,498	\$250	\$136	\$505,742
24	\$1,959	6	2	1.1%	\$817	\$133	\$950	\$475	\$158	\$173,000
25	\$2,798	1	1	1.1%	\$1,533	\$193	\$1,726	\$1,726	\$1,726	\$254,500
TOT:	\$2,398,924	782	268	9.4%	\$113,802	\$15,561	\$129,362	\$483 (Avg)	\$165 (Avg)	\$25,797,622

APPENDIX 6

REVIEW SYSTEM QUESTIONNAIRE

Summary of Responses (56 Total):

██████████ DISTRICT, CORPS OF ENGINEERS
Modification Study Interview Questionnaire

Date of Interview May - June 1985

INTRODUCTION:

This questionnaire is part of a study of modifications to military construction contracts within the ██████████ District in general and Fort ██████████ in particular. An underlying assumption of the study is that projects which receive careful pre-construction reviews have lower cost growth due to modifications than projects which are not reviewed. One of the stated objectives of the study is to evaluate the effectiveness of the District's review process. The purpose of this questionnaire is to obtain data to assist in making that evaluation.

1. Please identify your current job description, branch, and section.

Engr Division (29); Project Managers (10); Constr Reqs (6); Res Off (5); ^{QA}██████████(6)

2. Have you ever received any training in how to conduct either technical or constructability reviews?

Yes (25)

No (31)

3. If yes, describe which, how and when you received that training.

Formal courses/seminars (19); On-the-job training (6)

4. Circle the disciplines in which your training and/or experience gives you the expertise to conduct technical or constructability reviews (more than one answer acceptable):

a. Civil (25)

b. Architectural (16)

c. Mechanical (16)

d. Structural (22)

e. Electrical (15)

f. Other (specify) (7)

5. Circle the disciplines in which you normally conduct technical or constructability reviews (more than one answer acceptable):

a. Civil (22)

b. Architectural (16)

c. Mechanical (16)

d. Structural (20)

e. Electrical (12)

f. Other (specify) (5)

Assume that the projects referred to in the next three questions are within your primary area or discipline of expertise.

6. How much time do you need to properly review the following type projects?
(Consider only the time it takes to conduct the review.)

Small (less than \$500,000) projects - not complex

a. less than 1 working day (14)

b. 2 - 3 working days (31)

c. 4 - 5 working days (5)

d. 6 - 10 working days (9)

e. 11 - 15 working days (1)

f. over 15 working days (0)

Medium (\$500,000 - \$1,000,000) projects - medium complexity

- | | |
|--------------------------------|-----------------------------|
| a. less than 1 working day (3) | d. 6 - 10 working days (5) |
| b. 2 - 3 working days (18) | e. 11 - 15 working days (0) |
| c. 4 - 5 working days (24) | f. over 15 working days (1) |

Large (greater than \$1,000,000) projects - very complex

- | | |
|--------------------------------|-----------------------------|
| a. less than 1 working day (0) | d. 6 - 10 working days (22) |
| b. 2 - 3 working days (7) | e. 11 - 15 working days (5) |
| c. 4 - 5 working days (15) | f. over 15 working days (2) |

7. Given (your) (the people under your supervision's) normal daily work requirements, how long prior to when comments are due do (you) (they) need in order to perform a thorough technical or constructability review for:

Small (less than \$500,000) projects - not complex

- | | |
|-----------------------------|-----------------------------|
| a. 1 - 5 working days (17) | d. 16 - 20 working days (4) |
| b. 6 - 10 working days (19) | e. 21 - 25 working days (6) |
| c. 11 - 15 working days (5) | f. over 25 working days (1) |

Medium (\$500,000 - \$1,000,000) projects - medium complexity

- | | |
|------------------------------|-----------------------------|
| a. 1 - 5 working days (5) | d. 16 - 20 working days (3) |
| b. 6 - 10 working days (20) | e. 21 - 25 working days (6) |
| c. 11 - 15 working days (15) | f. over 25 working days (3) |

Large (greater than \$1,000,000) projects - very complex

- | | |
|------------------------------|------------------------------|
| a. 1 - 5 working days (1) | d. 16 - 20 working days (12) |
| b. 6 - 10 working days (7) | e. 21 - 25 working days (8) |
| c. 11 - 15 working days (16) | f. over 25 working days (8) |

8. On the average, how long prior to when comments are due are (you) (the people under your supervision) given to do reviews for:

Small (less than \$500,000) projects - not complex

- | | |
|-----------------------------|-----------------------------|
| a. 1 - 5 working days (22) | d. 16 - 20 working days (3) |
| b. 6 - 10 working days (14) | e. 21 - 25 working days (1) |
| c. 11 - 15 working days (8) | f. over 25 working days (0) |

Medium (\$500,000 - \$1,000,000) projects - medium complexity

- | | |
|------------------------------|-----------------------------|
| a. 1 - 5 working days (11) | d. 16 - 20 working days (3) |
| b. 6 - 10 working days (23) | e. 21 - 25 working days (1) |
| c. 11 - 15 working days (10) | f. over 25 working days (0) |

Large (greater than \$1,000,000) projects - very complex

- | | |
|------------------------------|-----------------------------|
| a. 1 - 5 working days (7) | d. 16 - 20 working days (4) |
| b. 6 - 10 working days (18) | e. 21 - 25 working days (3) |
| c. 11 - 15 working days (14) | f. over 25 working days (2) |

9. What percentage of your time during a "typical week" is spent on each of the following activities (circle "0%" for those activities that do not apply to you):

Technical/Constructability Reviews:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Engineering Design:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Contract/Design Modifications:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Field Inspections:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

General Office Correspondence/Admin:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Meetings:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Shop Drawing Review:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Coordination/Communication Between Corps, Contractor, DEH, A/E:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

Other (specify) _____:

a. 0% b. 1%-5% c. 6%-10% d. 11%-20% e. 21%-30% f. 31%-50% g. Over 50%

10. Prioritize the items shown in the previous question. Prioritize only those items that pertain to your work. You are asked to answer this question in two ways. First, show the priority that you feel SHOULD be assigned to each item. Second, show the priority that, based on your experience in the _____ District, you feel "the system" currently assigns to each item. Use "1" for the top priority with increasing numbers indicating items of lesser priority. Enter "0" or "N/A" for those items that do not apply to you:

Activity	Reviews as:		Priority
			As Is
a. Technical/Constructability Reviews	Top Third:	14	12
b. Engineering Design	Middle Third:	20	19
c. Contract/Design Modifications	Bottom Third:	10	15
d. Field Inspections			
e. General Office Correspondence/Admin			
f. Meetings			
g. Shop Drawing Review			
h. Coordination/Communication Between Corps, Contractor, DEH, A/E			
i. Other (specify) _____			

NOTE: Only time spent on modifications collated.

11. For what percentage of the reviews that (you) (the people under your supervision) have conducted did (you) (they) visit the site as part of the review process:

a. 0% (19) b. 0 - 25% (18) c. 25 - 50% (3) d. 50 - 75% (4) e. 75 - 100% (6)

12. The reason(s) (1) (the people under my supervision) do not visit sites as part of the design review process are (more than one answer possible):

a. Insufficient funds budgeted (22)
b. Competing work requirements (32)
c. I do not feel it is necessary (5)
d. Insufficient time due to short suspense dates (28)
e. Other (specify) (9)

13. How familiar are you with ^{District} Regulation 1110-1-1, "Review of Plans and Specifications"?

a. Have never seen it (24)
b. Have seen a copy but never read it (10)
c. Have read it, but not thoroughly familiar with contents (14)
d. Thoroughly familiar with contents (7)

14. Sufficient time is available to do thorough technical or constructability reviews:

a. Always (1) b. Most of the time (13) c. Sometimes (27) d. Rarely (10) e. Never (3)

15. Identify the reason(s) for those occasions when sufficient time for reviews IS NOT available. (More than one answer possible):

a. Insufficient funds budgeted (14)
b. Competing work requirements (37)
c. Not enough information provided (9) (all from Engineering Division)
d. Incomplete plans/specifications (15)
e. Short suspense dates (36)
f. Other (specify) (5)

All answers summed together:
Always=124 Sometimes=8 Never=0
Mostly=32 Rarely=1

16. Identify how often you think thorough technical or constructability reviews of the following size projects are necessary:

Small (less than \$500,000):

a. Always b. Most of the time c. Sometimes d. Rarely e. Never

Medium (\$500,000 - \$1,000,000):

a. Always b. Most of the time c. Sometimes d. Rarely e. Never

Large (over \$1,000,000):

a. Always b. Most of the time c. Sometimes d. Rarely e. Never

All answers summed together:
 Always=15 Sometimes=12
 Mostly=33 Rarely=4
 Never=2

17. Identify how often you think the District should conduct thorough technical and constructability reviews of projects designed by the following agencies:

Designed by contracted A/E firms:

- a. Always b. Most of the time c. Sometimes d. Rarely e. Never

Designed by DEH in-house personnel:

- a. Always b. Most of the time c. Sometimes d. Rarely e. Never

Designed by District in-house personnel:

- a. Always b. Most of the time c. Sometimes d. Rarely e. Never

18. Valid review comments are checked to insure they are incorporated into the final design:

- a. Always (12) b. Most of the time (13) c. Sometimes (21) d. Rarely (7) e. Never (0)

19. The individual who checks to insure comments are incorporated into the final design is (more than one answer possible):

- a. The reviewer (24) d. The project manager (30)
 b. The section chief (5) e. nobody (5)
 c. The branch chief (2)

20. Estimates prepared by the District for modifications are accurate:

- a. Always (0) b. Most of the time (19) c. Sometimes (15) d. Rarely (6) e. Never (0) f. Don't Know (15)

21. When performing technical or constructability reviews, (I) (the people under my supervision) use a checklist to identify which items/areas are to be reviewed:

- a. Always (1) b. Most of the time (8) c. Sometimes (13) d. Rarely (8) e. Never (17)

22. My training and experience gives me the expertise to conduct thorough and detailed technical or constructability reviews within my area or discipline:

- a. Always (16) b. Most of the time (29) c. Sometimes (6) d. Rarely (2) e. Never (0)

23. Technical or Constructability reviews are done at all required design stages (i.e. 35%, 90%, final) for new work designs:

- a. Always (6) b. Most of the time (23) c. Sometimes (18) d. Rarely (5) e. Never (1)

24. Technical or Constructability reviews are done at all required design stages for renovation designs:

- a. Always (4) b. Most of the time (17) c. Sometimes (23) d. Rarely (6) e. Never (1)

25. The same individual conducts reviews for all phases of design for each project:

- a. Always (3) b. Most of the time (22) c. Sometimes (20) d. Rarely (9) e. Never (0)

26. Thorough, detailed reviews save the government money:

a. Always (16) b. Most of the time (28) c. Sometimes (11) d. Rarely (2) e. Never (0)

27. Given all of the daily tasks (I) (the people under my supervision) must accomplish, the emphasis placed by "the system" (the District, DEH, Customer, etc.) on reviews is:

a. Too much (6) b. About right (29) c. Not enough (20)

28. For designs involving renovation work (as opposed to new work), site visits are routinely conducted (by me) (the people under my supervision) as part of the review process:

a. Always (4) b. Most of the time (13) c. Sometimes (6) d. Rarely (16) e. Never (15)

29. For designs involving new work (as opposed to renovation work), site visits are routinely conducted (by me) (the people under my supervision) as part of the review process:

a. Always (3) b. Most of the time (9) c. Sometimes (13) d. Rarely (12) e. Never (18)

30. Comments from previous reviews are readily available to individuals conducting subsequent reviews:

a. Always (16) b. Most of the time (16) c. Sometimes (13) d. Rarely (8) e. Never (0)

31. All valid review comments are incorporated into the final designs:

a. Always (6) b. Most of the time (23) c. Sometimes (22) d. Rarely (3) e. Never (0)

32. Individuals conducting reviews and providing comments are given feedback as to which of their comments are included in design changes and which are not:

a. Always (6) b. Most of the time (17) c. Sometimes (18) d. Rarely (11) e. Never (2)

33. (I) (the people under my supervision) have checklists for use as reference when conducting reviews:

a. Always (4) b. Most of the time (8) c. Sometimes (12) d. Rarely (8) e. Never (19)

Answer the following question on the basis of an absolute standard of quality. DO NOT qualify your answer.

34. The quality of the reviews (I) (the people under my supervision) conduct are as thorough and detailed as I feel the complexity of the project warrants:

a. Always (5) b. Most of the time (25) c. Sometimes (20) d. Rarely (0) e. Never (0)

35. How long have you worked for the Corps of Engineers (either in a District or DER position)?

- a. less than 2 yrs (5)
- b. 2 - 5 yrs (5)
- c. 5 - 10 yrs (16)
- d. 10 - 20 yrs (20)
- e. more than 20 yrs (10)

36. How long have you worked for the [REDACTED] District? _____

37. How much time have you spent as a design engineer (not limited to government work)?

- a. 0 (14)
- b. less than two years (5)
- c. 2 - 5 yrs (8)
- d. 5 - 10 yrs (10)
- e. 10 - 20 yrs (8)
- f. more than 20 yrs (11)

38. How much time have you spent in construction (not limited to government work)?

- a. 0 (10)
- b. less than two years (21)
- c. 2 - 5 yrs (6)
- d. 5 - 10 yrs (3)
- e. 10 - 20 yrs (6)
- f. more than 20 yrs (10)

39. How much time have you spent in management/supervision of engineering or construction (not limited to government work)?

- a. 0 (22)
- b. less than two years (4)
- c. 2 - 5 yrs (10)
- d. 5 - 10 yrs (7)
- e. 10 - 20 yrs (3)
- f. more than 20 yrs (4)

40. Please identify the highest academic level and all degrees you have earned. If you hold a degree (or degrees), please circle the type of degree (i.e. associates, B.S., M.A.) and show the discipline in which it was received.

- a. High School Diploma (4)
- b. College - no degree (2)
- c. Associates Degree (2)
- d. Bachelors Degree (B.S.) (B.A.) (41)
- e. Masters Degree (M.S.) (M.A.) (9)
- f. Other (0)

41. Do you hold a certificate as an Engineer in Training (EIT)?

yes (7) _____ no _____

(NOTE: Does not include those who are also licensed professional engineers)

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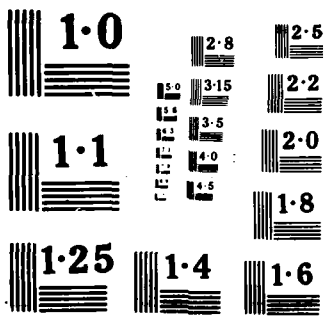
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42. Are you a licensed Professional Engineer (PE)? (NOTE: Includes all licensed professionals, such as architects, geologists, landscape architects, etc.)
yes (31) no (25)

43. Are you a certified Engineer Technician?

yes (1) no (55)

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